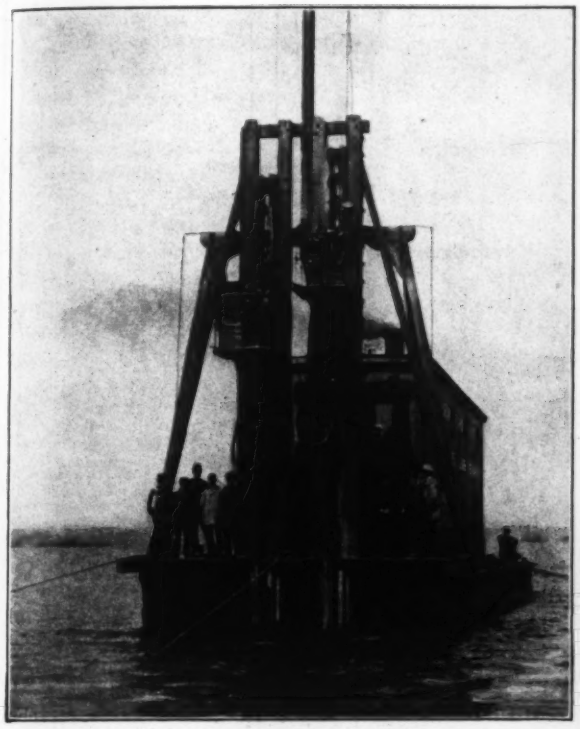

FIG. 22. SANFORD ROSS DRILLING BOAT WITH TWO SUBMARINE FRAMES

which show the method of drilling rock at Oak Point in the East River, New York City. The spuds are housed in movable guides overhanging the side of the vessel, as shown in Figs. 25 and 26. These guides are suspended from a track 15 ft. above the deck and can be traversed fore and aft a distance of 70 ft. by means of trolleys and ropes connected with a hoisting engine. Each steel spud is 43½ ft. long and has a 7x12-in. closed rectangular cross-section. Projecting guide flanges engage the sliding submarine-drill mounting (see Fig. 26). Wire rope, hauled in by a hoisting engine, passes from a point on the traveling frame down and around a sheave near the foot of the drill spud, then around another sheave on the traveling frame and thence to the hoisting engine. With this arrangement the spud can be quickly raised

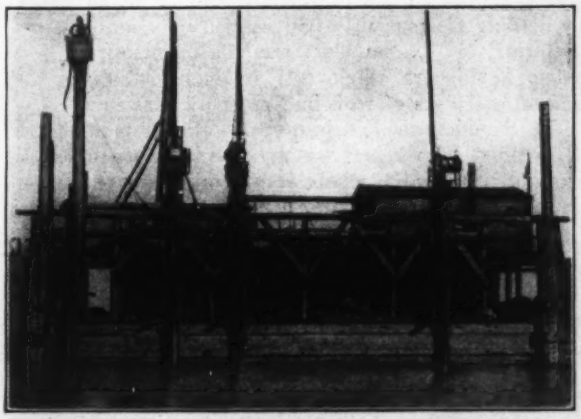

FIG. 23. DRILL BOAT OF ATLANTIC COAST CONTRACTING CO.
With four steel submarine frames and four anchor spuds

and lowered to any position. The drill is traversed vertically by means of a vertical screw with an effective feed of more than 10 ft., and is operated by an engine near the top of the drill spud.

Fig. 27 also shows the form of drilling tube used on the boat illustrated in Figs. 23 and 24. This tube is 4 in. in diameter and 20 ft. in length, which is sufficient to keep the top of the tube above the surface of the water. As the largest bit is 3½ in., this allows sufficient clearance. To the foot of the spud is attached a 6-in. pipe 8 ft. in length, which serves as a guide for the drilling tube. Both tubes are split their entire length with a slot about ½ in. wide, to permit raising the tubes without

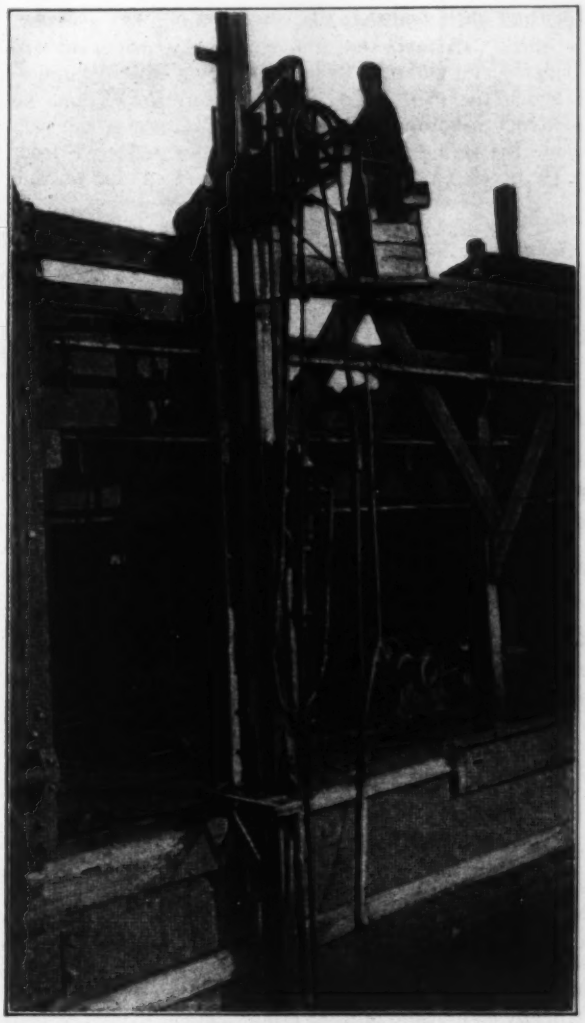

FIG. 24. SUBMARINE FRAME ON DRILL BARGE OF ATLANTIC COAST CO.

disturbing the firing wires connected with the charged hole. Both pipes normally rest on the surface of the rock to assist in starting the drill and to facilitate changing bits without losing the hole. The pipe also prevents mud from entering the hole and the slot permits the cuttings to be discharged.

The vessel described in the foregoing is self-adjusting to the variations of level due to waves or tide without affecting the operation of the drills. This is accomplished

by the automatic regulation of the pressure on the spud engines, which operate through rack-and-pinion motion four yellow pine spuds (14x14 in.x50 ft.) at the corners of the boat. As these engines are kept under a constant steam pressure, any increase in the load due to falling tide will cause the engines to overhaul against the steam pressure, and any decrease in the load due to rising tide will cause the engines to start up because of the steam pressure. Thus a delicate balance is maintained and the height of the boat above flotation is maintained constant. In this case the tide variations are from 5 to 7 ft.

The Drill

The drilling machine used with a submarine frame has the usual shell omitted, the frame taking the place of the shell. In fact, the frame resembles somewhat an elongated and enlarged drill shell having suitable guides in which the drill slides. The Sanford Ross frame is made of cast iron, with stiffening webs and flanges. Inside the frame is a feed screw, with an effective feed of 10 ft. or more, fitting the regular feed nut at the back of the drill. This screw hangs from the top of the frame and is geared to a small three-cylinder steam engine (Fig. 28), the speed of which is under perfect control of the operator. A handwheel is also provided, so that the drill can be raised or lowered either automatically or by hand, and by either method it may be fed down fast or slow, depending on the rate of cutting.

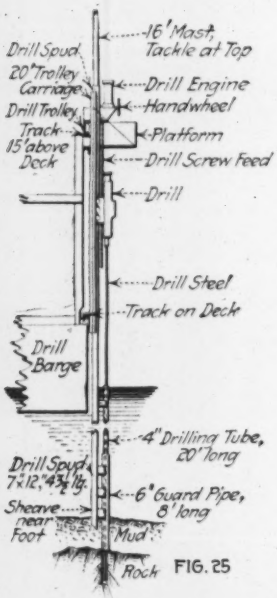

FIG. 25

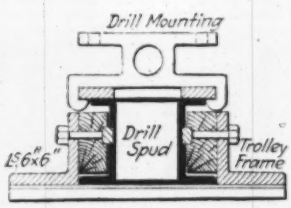

FIG. 26

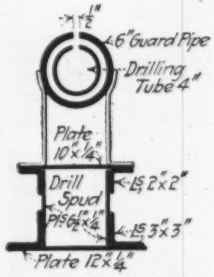

FIG. 27

FIGS. 25 TO 27. SUBMARINE FRAME DETAILS; ATLANTIC COAST CO.

Fig. 25—Drill spud and guide. Fig. 26—Sliding-drill mounting and trolley guide frame. Fig. 27—Spud foot and drilling tube

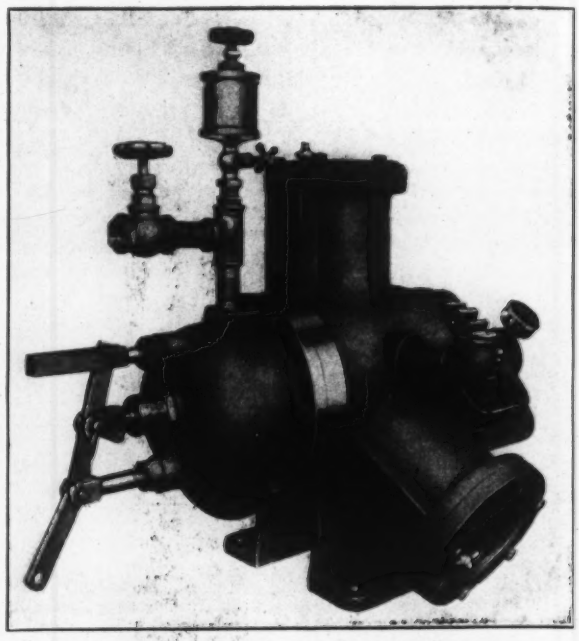

FIG. 28. THREE-CYLINDER STEAM ENGINE FOR OPERATING FRAME FEED SCREW

A drill commonly employed for this class of service has a 5½-in. cylinder diameter and 8-in. stroke. It is similar to the medium-weight drill previously described and illustrated in Fig. 13, with the exception of the mounting, lighter construction and a few minor differences. A heavier drill than this mounted on a submarine drilling frame would be too topheavy for the spud and hard to manage.

The submarine-frame method has been used successfully where all other principles have failed. Work with it is not as rapid as with the large drill boats described in the previous articles, but for changing tidal conditions it gives about as rapid a drilling method as has been devised. The accompanying tabulated data will give an idea of the performance of boats of the Sanford Ross type. For further data see "Rock Drilling," by Dana and Saunders.

Drilling in Shallow Water from a Raised Platform

In shallow water, with swift current or rough water, the drilling is frequently best carried on from a raised platform. W. L. Saunders was the originator of this system, having first employed it in the early 80's for the removal of ledges of rock in New York Harbor.

The Saunders method is probably the simplest means of drilling in shallow water, especially where swift currents, waves, high winds, considerable tide or a combination of these is encountered. It has the advantage of

TYPICAL RESULTS OF SUBMARINE-FRAME METHOD OF SUBAQUEOUS ROCK EXCAVATION

Boat	Location	Rock	Average Depths (Ft.) of Holes (Total) During Observation	Depth Drilled Below Pay Grade (Ft.)	Charge per Hole	Average Coal Consumption (Tons per Shift per Drill)	Holes Drilled per Boat Shift	Lin.Ft. Drilled per Shift per Boat	Average Depth (Ft.) per Drill per Hr., Inc. Delays	Cu.Yd. Pay Rock per Shift per Boat	Low-Water Channel Depth, Ft.	Spacing of Holes, Ft.
Eastern Dredging Co.[1]	Lovejoys Narrows, Kennebec River, Me.	Slate and flint	5	3¾	20 lb., 60%	1¼	8	40	2	7.4	18	5x4
Atlantic Coast Contracting Co.[2]	East River above Hell Gate, N. Y.	Gneiss, quartz, mica schist and granite	7	3	60% cartridges 2½x16 in.	..	Holes of various depths	..	2.25	...	29	4x4

[1] Boat fitted with Sanford Ross frames and Ingersoll-Rand drills. A shift crew comprised 2 drillers, 2 helpers, 1 blaster, 1 smith and 1 smith's helper; one 10-hr. shift per day.

[2] Wooden boat 95x28x8 ft. with structural-steel drilling frames and Ingersoll-Rand Drills. Shift crew of 4 drillers, 4 helpers, 1 fireman, 1 engineer, 1 smith, 1 smith's helper, 1 machinist, 1 captain; two 10-hr. shifts per day.

low initial cost, although the equipment must necessarily be lighter and of smaller capacity than that used on drill boats. Pontoons of air-tight barrels are generally employed to float the platform, Fig. 30, into position. It is supported on four timber spuds as in deep-water drilling, but is usually lifted clear of the water during work. The platform is built with slots over which tripod drills are set in much the same manner as on land. The platform is made of timbers, trussed to insure rigidity, and the spuds are of sufficient length to reach bottom at high water and raise the staging above the wash of the waves. The slots are spaced according to the required location of the drill holes and run practically the full width of the platform. A pipe or beam, which may be shifted, is supported on a timber frame, from which are suspended blocks and tackle or small chain hoists for raising and moving the drills, steels and tubes. A hand winch on the staging is employed for raising the platform or for lifting the spuds.

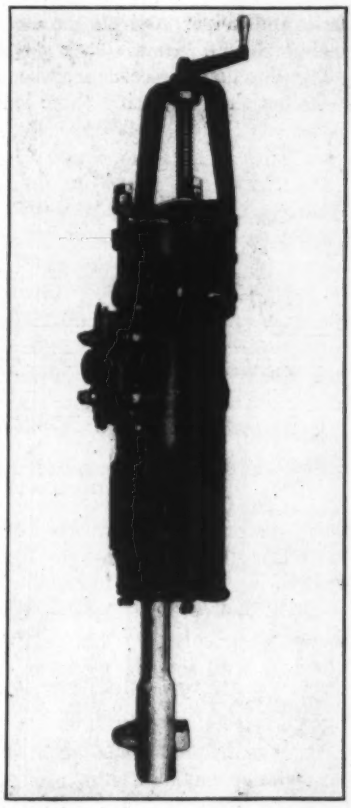

FIG. 29. DRILL FOR SUBMARINE FRAME (IN SHORT GUIDE FRAME)

A regular tripod drill is used, with the tripod legs mounted in a wooden A-frame which can be moved along the deck to the desired location. The A-frame (Fig. 31) is made of heavy oak timbers and has metal plates with holes for the tripod points to rest in. It is smooth and level on the bottom, with the edges and corners rounded so that it will easily slide along the platform. By means of heavy pins projecting from the sides one man with a crowbar can shift the heaviest drill. Staples are sometimes used for securing the frame to the platform.

Drills and Steels for Platform Work

The steels employed in the platform and floating-raft methods of drilling are the same as those used for land drilling, and the variations in length depend on the feed of the drill shell, which is usually 30 in., although a 48-in. feed is not uncommon. Long steels are preferable, but by employing an extension piece having a regular chuck with a U-bolt on each end (Fig. 31) and extension steels, ordinary steels may be used for this kind of work.

The sizes of drills used for this method are usually smaller than those for the other kinds of submarine work described previously, cylinder diameters between 3¼ and 5½ in. being the more usual sizes.

Telescopic drilling tubes, as previously illustrated, are the most convenient means of overcoming difficulties with mud or sand covering. These tubes may be easily arranged to slide in ways along the platform slots. Both drilling and charging are done through these tubes. A waterjet is invaluable for keeping the drill holes free. This method admits of "single-hole" blasting without removing the platform, provided proper care is taken not to set off a hole too close to a spud or where the rock surface is too close to the platform.

In the barge method the steam boiler is usually located right on the barge, but in the platform method it is customary to accompany the platform with a scow upon which the boiler, auxiliaries, stock of steels and blacksmith's outfit for sharpening the steels are located. The scow is moored alongside the platform and connected to it with a gangplank.

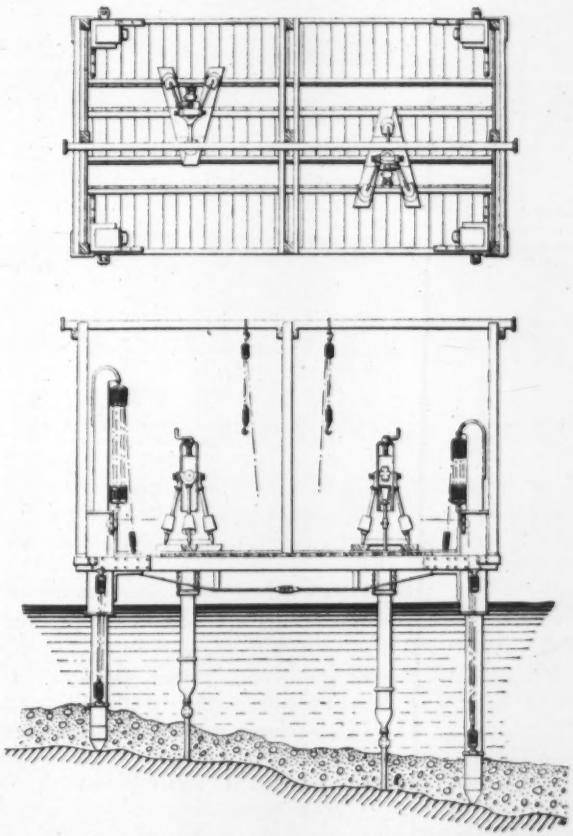

FIG. 30. SAUNDERS RAISED DRILLING PLATFORM

No recent data are available covering the raised platform method, but, as the drilling conditions described in the following paragraphs are somewhat similar to those of the platform method, the figures convey some idea of the results to be expected from the Saunders method.

Drilling in Shallow Water from Floating Pontoons

The manipulation of the drills by the fourth method is practically the same as with the Saunders system, but the rafts or pontoons are not raised from the water. This method is practicable only in shallow inland waters, where the water level does not change appreciably.

An interesting and thoroughly representative example of the use of pontoons for subaqueous drilling is referred to in the "Professional Memoirs" of the Corps of Engi-

neers, United States Army, September-October, 1913. The United States Government cut a channel through Tuscumbia Bar in the Tennessee River, about 2 mi. long by 150 ft. wide by 5 ft. deep at extreme low water.

The type of drill floats finally adopted for this work consisted of 13 pontoons, 1x5x25 ft., put together so as to leave a clearance of 1 ft. between pontoons. This made the overall dimensions 25x77 ft. There were three of these units in operation and attached to each was a drill

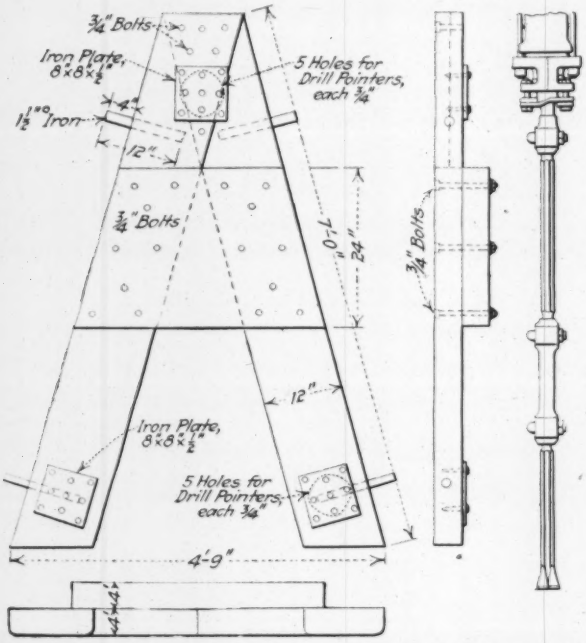

FIG. 31. DRILL BASE FRAME AND EXTENSION CHUCK

tender. Each float carried, upon A-frames, eight steam-operated 3¼x6½-in. tripod drills. At one setting of a float, holes could be drilled halfway across the channel.

To prevent the holes from filling with gravel and silt, the drilling was done through a pipe 3 or 4 in. in diameter (Fig. 33). From three to five drill bits were used in putting down each hole, depending on the depth of rock. The spacing was 4x6 ft. and the holes were put down to a depth of 9 ft. below low water. The spacing adopted at first was greater and the holes were not drilled so deep, but under those conditions the rock was

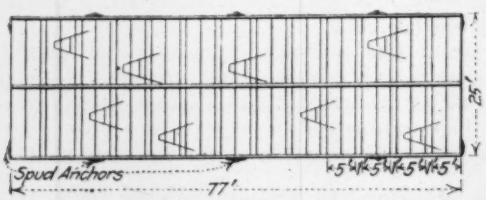

FIG. 32. PLAN OF DRILL FLOAT USED AT TUSCUMBIA BAR, TENNESSEE RIVER

often thrown out in large chunks, necessitating subsequent blasting with "mud caps."

The drilling rafts used at Tuscumbia Bar were floated into position, with the pontoons pointing in the direction of the current flow and the spuds lowered to prevent movement. Fig. 34 shows how the drills were managed. Under favorable conditions it required almost an entire day, with a double crew, to drill out, load and detonate all the charges for one setting of the drilling float.

During the first season the steels were sharpened by hand, but during the second season a compressed air sharpener was installed on one of the boats, and a blacksmith and helper kept all the steels for the 24 drills in good condition.

The Tuscumbia records may be summed up as follows: Holes per shot, 72, using three batteries simultaneously;

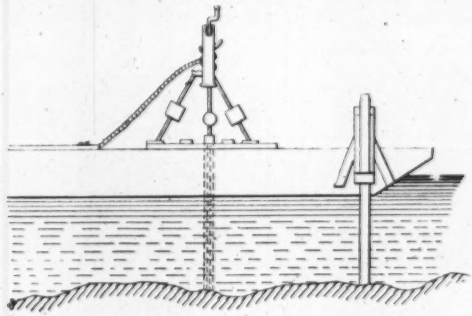

FIG. 33. ELEVATION OF ONE END OF TUSCUMBIA BAR FLOATS

charge per hole, 6 to 10 sticks of 80% gelatine dynamite; linear feet drilled per day per float, 432; average depth per drill per hour, 3.3 ft.; average rock excavated per day per float, 380 cu.yd. These figures were based on a 16-hr. day (two shifts). The depth of holes ranged from 3 to 8 ft., with the average about 6 ft. Steels were used in 2-ft. changes, with bits ranging from 1¾- to 2½-in. gage and steel diameters from 1¼ to 1½ in.

At Buck Island Shoals, about 3 mi. below Tuscumbia Bar, similar methods were used in drilling soft oölitic limestone. This rock cost about one-half as much to drill per linear foot as the hard blue flint-limestone rock at Tuscumbia Bar.

Special Schemes Often Needed

Although the more usual methods of subaqueous drilling have been outlined in this and the two previous articles many occasions have arisen in which none of these methods were suitable to meet special conditions. Cases have been encountered both on the sea and on inland waters where, on account of the difficulty of handling vessels, it became necessary to mount derricks on ledges of rock and operate the drilling machines suspended by chains from them.

FIG. 34. FLOAT AND BLASTED CHANNEL, TUSCUMBIA BAR, TENNESSEE RIVER

In a very recent case in England it was desired to remove 7 ft. from the face of a massive concrete wall about 60 ft. in height, forming a dock with 54 ft. below water. It was decided to put in a row of closely spaced holes, each drilled to the full depth. An ordinary submarine drill mounted on a drill wagon (the first expedient considered) was not thoroughly practicable on account of the extreme depth of holes. For these exceptional conditions a portable core drill, extracting a 2½-in. core, was found to be a much more satisfactory outfit.

While constructing the sewer outfall of Manchester, Mass., during the latter part of 1914, two small ledges were encountered in the trench at a depth of about 16 ft. at low tide. A hand hammer drill was purchased and was operated by a diver—a decidedly novel method of using this type of drill. The drill was operated by steam, the exhaust of which at first caused annoyance to the diver. This was easily remedied by bringing the exhaust to the surface through a length of common garden hose.

Rules for Efficiency Ratings: Municipal Civil Service

The Bureau of Civil Service of the City of St. Paul, Minn., has recently adopted a new set of rules and regulations, some of the most interesting features of which relate to the manner in which it is proposed to rate employees for efficiency, character and conduct.

While efficiency records have become recognized essentials in large organizations under civil service, there is quite a variety of methods employed in arriving at them. The St. Paul rules and regulations are evidently designed to eliminate, as far as possible, the personal equation (or perhaps bias) of the officer primarily responsible for the ratings and are therefore unusually elaborate.

The factors used in rating the efficiency, character and conduct of employees are under the following heads: (1) Quality of work; (2) attendance; (3) discipline.

Grading for Quality of Work

In fixing a numerical value for quality of work, reasons are to be given for any exceptionally low or high marks. The following is the system of numerals used and the character of work to which they refer: Above 85, exceptional; between 85 and 80, very good; between 80 and 75, good; between 75 and 70, fair; below 70, poor.

The subfactors used in marking the quality of work are uniform for all positions having duties of the same general character and of substantially similar authority, importance and responsibility. The definitions and weights of the subfactors that are used in marking the quality of work are as follows:

(*A*) Ability—ability to perform the duties of the positions, physical ability, general health, endurance, technical ability, special knowledge, mechanical skill, neatness of work, originality, resourcefulness, initiative, ability to direct work and to manage men, executive ability, sense of order, system, judgment, discretion, tact.

(*I*) Industry—Alertness, promptness, speed, industry, perseverance, energy, diligence, willingness to work, quantity of work.

(*R*) Reliability—Certainty of action, sobriety, health, accuracy, exactness, freedom from errors, truthfulness, attention to duty, faithfulness.

The following are the weights of subfactors to be used in arriving at efficiency, character and conduct markings for engineering employees:

	(A)	(I)	(R)
Drafting and detailing	0.4	0.4	0.2
Field and construction	0.4	0.3	0.3
Designing and estimating	0.5	0.2	0.3
Executive, specialized supervision, expert	0.5	0.2	0.3

Attendance and Discipline Demerits

No positive marks are given for attendance or discipline, but demerits are charged for infractions of regularly prescribed rules and regulations and for other delinquencies. In all deductions five demerits equal one point in efficiency, character and conduct markings for quality of work as follows:

Attendance—Tardiness; three demerits are given for more than five minutes and not exceeding one hour, and five for more than an hour. Absence without leave brings five demerits for each day. Absence without leave for three days or less in any month is investigated by the head of the department or bureau. Absence without leave for four days in any three months is cause for investigation by the Civil Service Bureau and for suspension.

Absence with leave not exceeding 15 days brings half a demerit for each day of the period; one demerit for each day in excess of the 15 days. The penalty, however, does not extend for more than a period of one month. Absence on sick leave not exceeding 30 days receives half a demerit for each day. No efficiency, character and conduct credit is allowed for overtime.

Discipline—The mark for discipline is obtained by penalties for laxity in observation or violation of established rules and regulations, failure to report, incivility, objectionable deportment or manner, inebriety, indolence, lack of personal neatness and improper habits.

If suspension is imposed for disciplinary purposes the demerits are as follows: For suspension of one day ten demerits are given. For a suspension of more than one day and less than seven working days, 15 demerits. For more than six and less than 13 working days, 25 demerits. For more than 12 and less than 28 working days, 40 demerits. When demerits are so awarded there are no additional demerits under "attendance" for the suspension period.

The total demerits reported with any individual efficiency, character and conduct report are added and the sum divided by five and the result subtracted from the marking for quality of work. The remainder is entered on the report as the net efficiency, character and conduct mark.

All net-efficiency markings are entered from the reports upon a card record. The card is subdivided by departments, the departments by payrolls, the payrolls by alphabetical arrangement of the names. The reports are then filed alphabetically by departments and chronologically within departments. Markings are not entered finally until after investigation or until approved by the examiner.

A Large Tidal Lock which will give access to the new harbor at Chemulpo, Korea, is being built in accordance with competitive plans prepared by Henry Goldmark, consulting engineer, New York City, for the McClintic-Marshall Co., of Pittsburgh, Penn., the successful bidders on the entire equipment. Mr. Goldmark has been appointed to take charge of the construction in the United States of the lock gates, sluice valves, operating machinery and electrical equipment.

Pumping California Crude Oil

By C. P. Bowie*

SYNOPSIS—For pumping the lighter California oil through pipe lines it is heated and thus rendered fluid enough so that it will flow readily. The author describes from his own experience the method by which engineers proceed to lay out the pipe lines and pumping stations so that the maximum amount of oil may be transported.

The crude petroleum produced from the California oil fields is a dark-colored, thick, viscous liquid, emitting, especially when first drawn from the wells, a strong odor of sulphur. The product from different fields and different wells varies in gravity between 12° and 38° Bé. Most of the present-day production lies between 14° and 28° Bé., or between 0.9722 and 0.8861 specific gravity. The wells from which it is produced vary in depth from 200 to 4,000 ft.; the lighter oils being usually found in the deeper wells. In the Kern River field, which lies in the southeasterly end of the San Joaquin Valley near the city of Bakersfield in Kern County, and which was one of the first inland fields to be extensively developed, the producing sands are seldom found at a depth greater than 1,300 ft.

The Rifled System of Oil Pumping

Fully 80% of the oil in this field is of a gravity heavier than 15° Bé. The difficulty in moving this viscous material through pipe lines, especially in cold weather, has given rise to the invention and development of a process of pumping known, locally, as the "Rifled System," the like of which, so far as I am able to determine, exists in no other country in the world.

This system was invented by J. D. Isaacs, now Consulting Engineer of the Southern Pacific R.R., and Prof. Buckner Speed, of the University of California, and has been successfully used for the past eight years by the Associated Pipe Line Co. in transporting oil from the Kern River field to Port Costa, a town on San Francisco Bay 26 mi. east of Oakland and 283 mi. distant from the oil field.

This system[1] consists in pumping cold oil of from 13 to 15° Be., together with about 10% by volume of water, through an 8-in. pipe that is corrugated spirally, or "rifled." The rifles are put into the pipe as it is made by running each length with a twisting motion through a set of rolls consisting essentially of wheels, about ¼ in. wide, which push indentations into the pipe from the outside. The rifles make one complete revolution in 10 ft. of length of pipe and give to the interior much the same appearance as the inside of a gun barrel.

In operation water is forced into the pipe along its inner periphery through an injection nozzle surrounding the pump discharge and at a distance of about 10 ft. from the pump. Since the pipe is already filled with oil, the water being injected in this manner forms a film between the core of oil and the walls of the pipe itself. As the mass moves forward the rifles give to it a whirling motion and because of the greater specific gravity of the water, the centrifugal force produced holds the film of water in place, thus keeping the oil from coming in contact with the pipe and consequently greatly reducing the frictional resistance.

The Hot-Oil Pumping System Described

Experience, however, has shown that the rifled-line system of pumping is limited to oils of a gravity not lighter than 15° Bé. Oils of higher gravity will form an emulsion with the water and produce a mixture that is not only very difficult to pump and often expensive to separate into its integral parts on arrival at the terminal,

FIG. 1. A TYPICAL PUMPING STATION ON A CALIFORNIA OIL PIPE-LINE

but that also may greatly reduce the oil contents of the line, since at each pumping station it becomes necessary to add water to the mixture in order that the free water in the pipe may be kept up to the necessary 10%. While this system works satisfactorily with some grades of heavy oils, it is not likely that it will ever be used in fields which produce light as well as heavy oils, for the reason that when light oil can be obtained it is always possible, by mixing the low-gravity with the higher-gravity, to obtain a product that can be successfully pumped by what is known as the "hot-oil process."

This system of transporting the oil consists in pumping it dry, that is, without the addition of water, and of heating it at the initial and each succeeding station to such a degree of temperature that the gravity may be raised sufficiently to produce a fluidity commensurate with that necessary to secure the required velocity of flow, maintaining at the same time a pressure at the pumps within the limit of their design. While the methods pursued in designing a "hot-oil" system would in many respects apply to a "rifled" system, the following discussion assumes that the oils to be transported will be heated to the required temperatures and pumped without the addition of water.

Fixing Location for Oil-Pipe Line

In preparing the surveys for a pipe line, the work proceeds in much the same manner as the preliminary survey for a railroad. The engineers should first make a reconnaissance of the country through which the proposed line is to pass, for the purpose of noting its more promi-

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[1]A paper by Mr. Isaacs describing this process in detail was published in "Engineering News," June 7, 1906, p. 640.

nent features and acquiring a general knowledge of the topography in order that he may select the most suitable route. Due consideration should be given to the prospects of securing a suitable water-supply for the various pumping stations. Excessively hilly country should be avoided because, even though it offers the shortest route for the line, it may require the building of expensive roads to carry on the construction and may make the cost of maintenance and operation high.

The floors of old lake beds, where the soils contain a high percentage of alkaline salts, may also well be avoided when possible, since through such territory depreciation of the pipe from corrosion is very rapid, and expense and more or less elaborate coverings must be resorted to, which at best afford probably only temporary protection.

A route along the bank of a stream is seldom a desirable one, especially where the flow is torrential during the wet season. Such streams may change their course very rapidly during times of high water and destroy considerable sections of the line by undermining it. Detours from an otherwise desirable location may also be necessary on account of inability to secure right-of-way. This last objection to an alignment can, however, generally be overcome by condemnation proceedings or by compromise, and it is therefore usually unnecessary for the engineer, in his preliminary work at least, to give this phase of the procedure more than passing consideration.

When the route has thus been gone over in a general way, a transit line is run to which is tied in all section corners, monuments, etc., marking land surveys, also all adjacent buildings or other structures, and upon which is carefully noted all intersections with streams, railroads, wagon roads, streets, fence lines, pipe lines, power lines and whatever else crosses the proposed route. Stakes marked with the engineering station are set at intervals of 100 ft. or less, where necessary.

Immediately following the transit party come the levelman and rodman. Ground elevations are taken at each engineering station and at such intermediate points as are warranted by stream crossings or other changes in the topography.

As the field work progresses an alignment map and profile is made in the field office. This should be kept as nearly uptodate as possible in order that any errors in the instrument work may be discovered and the necessary corrections made in the field while the camp outfit is still in the vicinity. The field map and profile being only a rough copy, often made hurriedly and under the extreme of adverse conditions, it is usually advisable to prepare at least a new profile of the line in the office at headquarters when the field work is complete.

For convenience it is well to plot on this profile, beneath the ground elevations, a second line, called the "power profile," which represents the ground elevations divided by 2.3, or the static head in feet reduced to pressure in pounds per square inch.

The Pumping-Machinery Installation

In determining the number of pumping stations required for a system, it is usual to assume 800 lb. per sq.in. as an allowable maximum working pressure on the pumps. This figure is, however, only arbitrary, since 700 lb. or 600 lb. maximum pressure could be used if desired. Nearly all the trunk lines operating at the present time are composed of 8-in. pipe that is guaranteed by the makers to withstand a test pressure of 1,200 lb. per sq.in. and a working pressure of 800 lb. per sq.in., in view of which the pump manufacturers have been required to guarantee their machinery also for 800 lb. working pressure. So it is that this figure has become sort of a standard by which to design pumping systems and 8 in. the size of pipe to which other lines are referred.

Fluid Friction of the Oil in the Pipes

Regarding the flow of California crude oil through pipe lines, an amazingly small amount of reliable information is available. So many varying quantities enter into the problem of pumping by the hot-oil process, each one of which may prove to be an influential factor, that it is difficult to predict with any reasonable degree of assurance as to accuracy just what the results will be for any given hypothesis.

In the case of water we have a fluid whose gravity is practically constant and whose viscosity remains unchanged within the ranges of temperature maintained during its flow from one position to the other. The flow of oil, however, is influenced very largely by viscosity, and the viscosity factor depends not only on the gravity of the oil and the temperature at which it is pumped, but apparently also on its chemical constituents. This latter seems exemplified by the fact that a very decided variation in flow will often be noted in two days' run of a pumping station, although so far as can be determined, the gravity and the temperature of the oil remain unchanged, as well as atmospheric conditions.

Another reason for this dearth of knowledge is the fact that pipe lines now in operation, from which reliable data could be obtained, are practically all of one size and engaged in pumping, as nearly as possible, a maximum quantity of oil each day.

Within the knowledge of the writer the most reliable data at hand relate to oils from 16 to 28° Bé. and are limited to pipe lines from 12 to 20 miles in length. Between these limits reasonably accurate results can be obtained for lines from 4 to 10 in. in diameter by the use of the following formula:

$$Q = C\sqrt{\frac{P}{Le}}$$

Where

Q is the quantity of oil in barrels per hour;

C is a constant;

P is the initial pump pressure (plus or minus the static head between terminals) in pounds per square inch;

L is the length of line;

e is a factor dependent upon the size of the pipe used.

For values of C use the following:

Gravity of Oil.	Outgoing Temp.	Value of C
16° B.	142° F.	160
18° B.	136° F.	167
20° B.	130° F.	174
22° B.	125° F.	183
24° B.	119° F.	192
26° B.	113° F.	202
28° B.	107° F.	213

For values of e:

4-In. Pipe	6-In. Pipe	8-In. Pipe	10-In. Pipe
32.00	4.20	1.00	0.333

These figures are based on the assumption that the pipe line between stations is buried in dry ground to a depth of at least 2 ft. and that wherever the pipe passes over trestles of any considerable length it will be protected

against loss of heat by radiation, either by boxings filled with earth or bulrushes, or by wrapping the pipe with successive layers of building paper or other insulating materials.

Even were the temperature factor the only variable affecting the flow of the oil, it is obvious that one cannot hope to obtain exact results from the use of a formula, and no such claim is made for the one here given. It has, however, been found by repeated experiments that the figures are conservative and that between the limits as stated they can generally be depended upon to give results within a reasonable degree of accuracy—more often too small than too large.

The outgoing temperatures given, under values of C, for the various gravities of oil are an average of those which experience has shown to give the best results when pumping oil of that particular gravity.

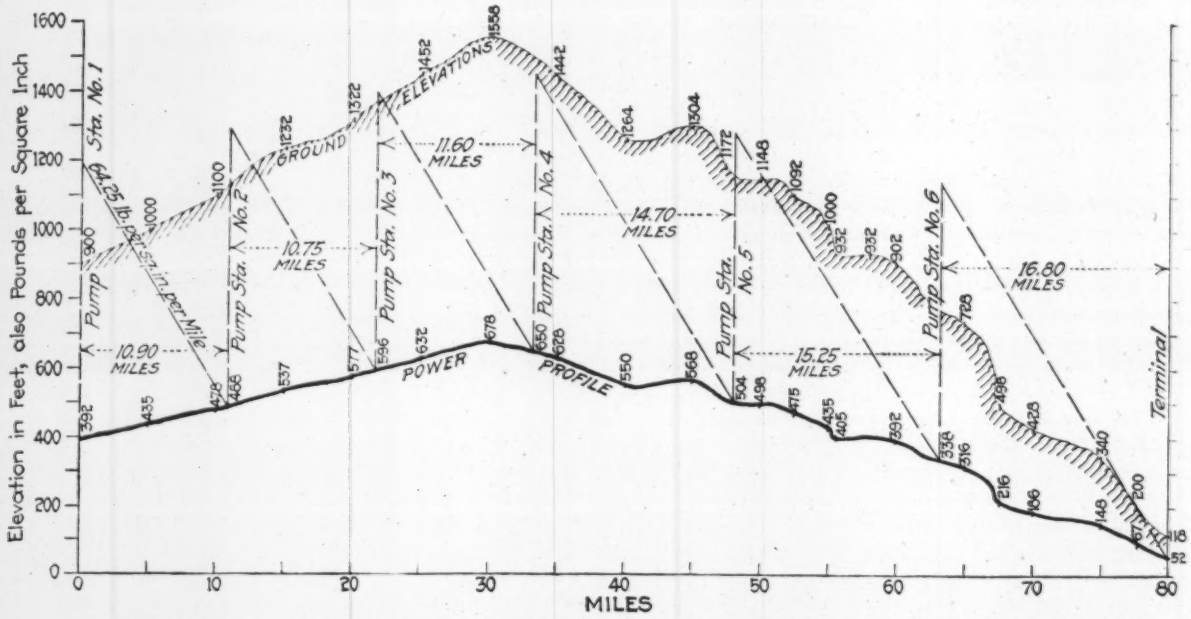

FIG. 2. GROUND PROFILE AND POWER PROFILE FOR AN 8-IN. OIL PIPE LINE, 80 MILES LONG, TO DELIVER 30,000 BBL. PER DAY OF 16° B. OIL. MAXIMUM LINE PRESSURE, 800 LB. PER SQ.IN.

A Typical Problem in Pipe-Line Design

Returning to the power profile reproduced herewith, suppose that we were called upon to design a system that will deliver 30,000 bbl. per day of oil of a gravity of 16° Bé. or higher, through an 8-in. pipe line, with a maximum working pressure on the pumps of 800 lb. per sq.in. We would design the system for 16° Bé. oil, since this would present the worst conditions and a line which would successfully deliver the required amount of this gravity of oil would easily live up to expectations with lighter oils.

From the formula it can be determined that a line of 8-in. pipe (on level ground) 13.1 miles in length will deliver 30,000 bbl. of 16° Bé. oil per day of 24 hr. with a working pressure at the pumps of 800 lb. per sq.in.; which is to say that to insure this delivery we must have an available head to overcome friction of 61 lb. per sq.in. per mile and must therefore lay out our hydraulic grade line with this end in view. Suppose that the proposed system is to be 80 miles in length with the initial station of sufficient height above the terminal to afford a static head of 340 lb. per sq.in. Then we must have a number of pumping stations which, multiplied by 800, the product added to 340 (had the terminal been lower than the initial point by the same amount we would have subtracted the 340) and the result divided by 80 will give a friction head per mile of at least 61 lb. per sq.in. By trial we see that five stations give 54.2 lb. per sq.in. per mile and six stations 64.2 lb. per sq.in. per mile. We must therefore use six pumping stations and in doing so could reasonably expect that our system would, in case of emergency, be capable of delivering a little more of the lowest-gravity oil than the requirement.

Plotting the Grade Line for Pipe

In plotting the grade line, it is more convenient to use the power profile than the ground elevations, since the points on the vertical scale representing pressures at pumping stations will by this method usually fall within the bounds of the profile sheet. To locate the pumping stations, begin at the sources of the line and lay off on the vertical scale a point representing 800 lb. plus the static head as shown on the power profile. Then on the vertical scale, at some convenient distance out from the source—say ten miles—plot the point which represents the pressure at this position on the line; which will be 642 lb. less than the first point plotted. A line drawn through these two points and produced to cut the power profile will locate on it the theoretical position where the pressure in the line becomes zero, or in other words where we will have to place another pumping station. Plotting on the vertical scale above this intersection a point representing 800 lb. plus the static head, we proceed as before, continuing until we reach the end of the line. As a check on the accuracy of the work, the last diagonal line, or gradient, should cut the terminal point of the profile.

It may happen that a pumping station so located will fall on ground the nature of which, because of swamps

or extreme roughness, presents physical characteristics undesirable for the erection of tanks and buildings. In such a case it is better to choose a pumping-station site opposite the one located, to the right or left of the line and make a detour to include it, than to move backward or forward a half-mile or more, thus causing a weak link in the system. If a detour is necessary the profile should be replotted and all the stations relocated.

Heating Stations Sometimes Necessary

If the contour of the country traversed between any two stations is such that the hydraulic grade line follows closely along the power profile without cutting it, the distance between stations may become so great that the loss of heat from radiation will materially retard the flow, and in order to keep the system up to capacity will require a line pressure at the pumps in excess of the safe maximum allowable amount. In this case it would be necessary to put in a heating station.

Such a station consists essentially of a bypass from the main line through which the oil can be passed into a manifold and thence into a number of smaller pipes, usually 4 in. in diameter. The latter traverse the gas flues of a furnace where the temperature of the oil is raised the desired amount, before returning again to a manifold and thence into the main line. The source of the heat is supplied by oil drawn from the line itself. The pressure is sufficiently reduced by means of a reducing valve and fuel oil is passed through coils arranged on the inner face of the firebox, where it is highly heated, and thence sprayed into the furnace, being so finely atomized that it burns with an even and almost noiseless flame, in which combustion is complete.

It may sometimes happen that the hydraulic gradient will cut the power profile at a certain point and then pass on well above it for a considerable distance before a definite intersection is reached. Where this is the case, the trench for that portion of the line which lies above the diagonal should be excavated well below the gradient; or, if this is impossible or too expensive, a detour should be run out on lower ground. It is always poor policy to lay any of the pipe above the hydraulic grade line, since the remainder of the line acts merely as a channel to deliver the flow, which will result in a remarkably large diminution of discharge.

The Value of Accurate Planning

One of the chief faults of pipe-line systems that have heretofore been constructed in California has been that too little heed was given to accurately surveying the proposed line and then making a detailed study of the profile with a view to locating the pumping stations at such positions that, as nearly as possible, a constant friction head might be maintained throughout the system for any desired working pressure. Where the pipe passes over high mountain ranges this is of course impossible with low working pressures, since on the upgrade side of the range there will always be required a certain amount of pressure to overcome static head. However, as the limiting capacity for which the system is designed is approached, there can be no excuse for not being able to deliver, with a constant working pressure throughout, approximately the same amount of oil at each pumping station.

Engineers engaged in the design and construction of oil-transportation systems will do well to hold paramount in their minds the fact that, after all, barrels per day delivered is the bread and butter of the system and that no effort should be spared to the end that the given quantity may be delivered with, as nearly as possible, an equal wear and tear on each station from beginning to end of the line.

The truth of the old adage that no chain is stronger than its weakest link is nowhere better exemplified than in oil pipe-line systems. If nine pumping stations have a daily capacity of 30,000 bbl. and the tenth of only 25,000 bbl., then the whole line has but a 25,000-bbl. capacity and whatever of time and money has been expended on bringing the nine stations to the greater capacity is wasted until the tenth can be strengthened.

Acknowledgment is made to E. G. Brua, Assoc. M. Am. Soc. C. E., for his kindly criticism and helpful suggestions in the preparation of this paper.

Civil-Service Examination for Water-Works Engineer

The City of St. Paul, Minn., recently conducted an examination for a water-works designing and construction engineer (salary $250 per month). The examination was open only to citizens of St. Paul, and of the four who took the examination not one passed. It was an unassembled examination—the application form, experience paper and question sheets were sent to the applicants, and the answers were written by them in their own homes or offices.

SPECIAL SUBJECT (WEIGHT 50)

Question 1. Describe in detail the most important engineering structure you have actually designed and which has been constructed in accordance with your design, stating the location, date of design and date of subsequent construction, preference to be given to water-works structures, such as reservoirs, filtration plants, etc.

Question 2. Describe some of the most important pieces of construction work, not to exceed five, which you have actually superintended, stating the date, period of time the construction was in progress and the approximate cost of the completed work.

SUBJECT: MATHEMATICS AND REPORT (WEIGHT 30)

Question 1. A water-works contemplates purchasing a pumping engine having a capacity of 15,000,000 gal. per 24 hr. Under the following operating conditions, what type of pump would be most economical to buy: Suction head, 8 ft.; discharge head, 170 ft. (includes friction in discharge line); steam pressure, 125 lb.; superheat, 0°; temperature of feed water, 190° F.; return tubular boilers, hand fired; coal contains 14,000 B.t.u.; cost $5 per ton (2,000 lb.), delivered?

This unit will be used to operate in conjunction with others in the same station during six months of the year—May, June, July, August, September and October.

Assume that a triple-expansion, vertical flywheel engine will cost $100 per water horsepower and having a guaranteed duty of 150,000,000 ft.-lb. per 1,000 lb. of dry steam; that a steam turbine geared to a centrifugal pump would cost $30 per water horsepower and have a guaranteed duty of 120,000,000 ft.-lb. per 1,000 lb. of dry steam. Assume that no additional boiler capacity will be required. Assume that foundations and revision of the building will cost $25,000 in case of a triple-expansion, vertical flywheel engine and $1,000 in case of a steam turbine and centrifugal pump.

The pump is to be purchased from the sale of 30-yr. bonds, bearing 4½% interest. This must be taken into account in your conclusions.

Assume that attendance and supplies would be the same for any type of equipment, estimating it to be $2,000 per yr.

Are there any other considerations which you would take into account in selecting the pump? If so, mention them, and give reasons for your answer.

Show the details of all calculations and the method of arriving at your result.

SUBJECT: EXPERIENCE (WEIGHT 20)

This subject is rated from the answers submitted by the applicant to the questions contained in the experience blanks.

Cause and Prevention of Storm Erosion on Gulf Coast

By Gerald O. Case*

SYNOPSIS—The recent hurricane on the Gulf coast not only caused serious damage to structures, as noted lately in an issue of "Engineering News," but also tore out large sections of beach and shore, with consequent destruction of property. Mr. Case made a personal inspection of many miles of the coast and reports here the results of his investigations. They apply not only to this particular shore line but to many others of a similar conformation.

Hurricanes are known to have periodically ravaged the Gulf coast for the past 150 yr., and they have not only caused many deaths and great losses to shipping interests, but have also done millions of dollars' worth of damage by injuring growing crops, destroying timber areas near the coast, killing livestock and damaging houses and business properties by wind action and flooding. A large amount of preventable damage has also been done by wave action and currents eroding the coast. The erosion has resulted in the loss of a considerable amount of land

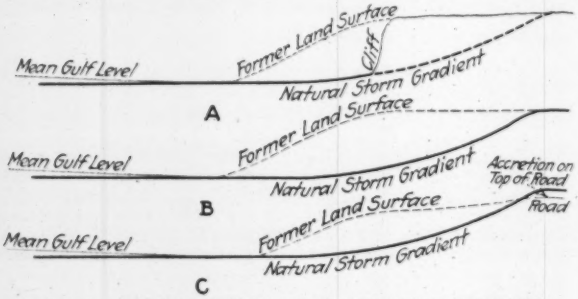

FIG. 1. THREE TYPES OF FORESHORE SECTION

and the destruction of houses, and a large amount of damage has been done to the coast roads and railway tracks, and unless prompt and effective measures are taken to prevent further erosion it will be impossible, at a reasonable cost, to maintain two of the most beautiful coast roads in the United States—those between Biloxi and Pass Christian and Bay St. Louis and Waveland, Miss. In the past no recorded study has been made of the causes of erosion on this part of the coast and the best means of preventing it.

Topography of Coast Line

The coast line of Mississippi is to a great extent sheltered by an outlying chain of sandy islands. The land abutting on the shore line is generally about 10 to 15 ft. above mean Gulf level. The soil is mostly sand and consequently easily eroded by wave action. In many places there are slightly depressed areas a short distance behind the shore line, which at times results in a considerable seepage of water through the sand ridge to the Gulf.

Mississippi Sound is essentially a naturally protected bay and one which under ordinary circumstances would be classified as an area subject to accretion and not erosion. As a rule erosion takes place at headlands and projecting parts of the coast and accretion occurs in sheltered bays and estuaries, and there is strong evidence to show that below mean-high-water level the Mississippi Sound is no exception to this general rule, the erosion caused by hurricanes being confined to the storm foreshore (area between mean-high-water level and the landward limit of the storm tide) above mean Gulf level. Below ordinary high-water level accretion takes place to a large extent through the action of vegetation which grows on the sea bed and arrests and consolidates sediment carried in suspension in the currents, and to the action of certain mollusks, chiefly oysters, which dwell on the bottom and contribute their share to the rising surface. On the east side of several accumulations of oyster shells projecting out into the sound and on the east side of Gulfport harbor land is being gradually reclaimed by salt-loving grasses accumulating material.

Record of September Storm of 1915

The first hurricane of which there appears to be any authoritative record was that of 1772. Other severe storms—each of which has continued the erosion caused by its predecessors—occurred in 1819, 1856, 1860, 1893, 1901, 1906, 1909 and 1915.

Although the erosion is confined to the areas above mean Gulf level, and there are often periods of several years when no appreciable erosion takes place, yet the net result, considered over the long period of time is that greater erosion takes place on the Mississippi coast than on many exposed coasts subject every winter to the undermining action of waves and currents. One reason for this is that although the storms on the Mississippi coast which cause erosion occur infrequently compared with storms causing erosion on the open Atlantic coast, yet when they do occur they are exceptionally severe. Another reason is that on the open coast the foreshore eroded during winter is in many cases repaired again by the forces of nature during the summer months. On the Mississippi coast the water falls back from the area eroded as soon as the storm subsides, and owing to the small range of tide is only covered by water during the time when the destructive forces are at work, and there is therefore no chance of nature assisting to repair the damage.

The hurricanes on the Gulf of Mexico practically always occur between the middle of August and the beginning of October. That of Sept. 29, 1915, as usual originated in the area known as the "doldrums" and approached the Gulf coast from a southeasterly direction. The center of the storm struck the coast at New Orleans, and altogether 300 mi. of the coast was more or less affected by the storm. Information supplied to the writer by the Weather Bureau at New Orleans showed that the maximum wind velocities were recorded at Burrwood, La., and were as follows:

Velocity, Miles	Periods in Minutes
124	5
116	19
108	60
106	60
96	60

The maximum wind velocity recorded at New Orleans for a 5-min. period was 88 mi. per hr.; the previous high-

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FIG. 2. RAILROAD DAMAGE NEAR BILOXI

FIG. 3. EROSION OF SHORE NEAR GULFPORT

FIG. 4. CONCRETE WALL WRECKED AT BAY ST. LOUIS

FIG. 5. ANOTHER VIEW OF BAY ST. LOUIS WALL

FIG. 6. TIMBER BULKHEAD DESTROYED, BAY ST. LOUIS

FIG. 7. SHORE EROSION NEAR MISSISSIPPI CITY

FIG. 8. WRECKED SEA WALL NEAR GULFPORT

FIG. 9. NO EROSION ON GRASSED FORESHORE

est velocity recorded was 66 mi. per hr. during the hurricane of 1909. The maximum rise of tide above mean Gulf level took place about 50 mi. east of the storm center, where the rise was approximately 20 ft. At Biloxi, Miss., the rise was about 9.75 ft.; at Pass Christian, Miss., 10.2, and at Bay St. Louis, Miss., between 10 and 11 ft. As soon as the wind turned round toward the southwest the water immediately began to fall. The figures indicate that the rises of tide were at least 1 ft. above those recorded during the 1909 hurricane.

If we can take as reliable the information handed down to present residents of Pass Christian as to places reached by the tide during the hurricane of 1819, it would appear that during that storm the tide rose about 1 ft. higher than it did on Sept. 29 last.

The amount of the rise of the tide is of course largely dependent on the contour of the coast, the maximum rise taking place at or near the heads of confined bays, where the water naturally piles up. During the last hurricane the maximum recorded rise was at the east end of the Mississippi Sound, where the water was confined and unable to escape to southward.

As the water rises very rapidly, at first the lower part of the foreshore is subject to breaking waves for a comparatively short time compared with the upper part.

No reliable information was obtained as to the height of the waves during the hurricane, but owing to the existence of the outlying chain of sandy islands the height must have been small compared with the height of storm waves on the open coast.

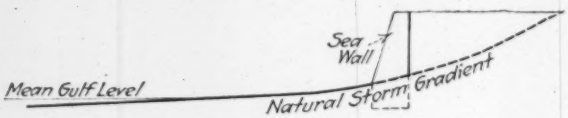

FIG. 10

FIG. 10. POOR LOCATION OF SEA WALL

The height of waves, as is well known, depends on the "fetch," or distance, of open sea across which the wind blows before reaching the coast. Stevenson's formula for this height of waves is: $h = 1.5 \sqrt{f}$, where f is the "fetch." Between Bay St. Louis and Biloxi the distance between the outlying islands and the shore, measured diagonally across, is nowhere more than about 14 mi. Using the foregoing formula, it would appear that the wave height was probably not more than about 5 ft. 6 in.

Damage to Foreshores

The illustrations give a good idea of the erosion caused by the hurricane. In many places between Biloxi and Waveland from 10 to 50 ft. of land was washed away and the fine shell road which formerly existed along this part of the coast has been breached in numerous places and will probably cost from $200,000 to $300,000 to replace. The line of the Louisville & Nashville Ry. was badly damaged, notably at Chef Menteur and Rigolets. At the former place 319 ft. of track was destroyed and at the latter about 900 ft., causing the direct train service on the coast line between Mobile and New Orleans to be suspended for about a month. The coast line of the Gulfport & Mississippi Traction Co. was also wrecked most of the way between Biloxi and Pass Christian, a distance of over 20 mi. This line previous to the storm was in front of the coast road.

Although very serious and extensive erosion took place over a length of more than 30 mi. of the Mississippi coast, the amount of erosion was by no means uniform, and in some places little or no erosion happened.

A careful examination of the local conditions showed that the outlying islands have a considerable influence in protecting the coast. The east beach at Biloxi, which is largely sheltered by Deer Island, suffered much less than the west shore, which is less protected. It was also noticed in several places that where accumulations of oyster shells project into the Sound, the erosion was more marked in the leeward (westward) side than on the east side. At Gulfport harbor the difference between the erosion on the east and west sides of the harbor was particularly noticeable; and while little damage was done on the east side, where natural accumulation has been taking place below mean-high-water level, on the west side there was severe erosion.

Various Influences at Work

It was also apparent that the gradient of the storm foreshore had a very powerful influence in determining the amount of erosion taking place. Where there was a gradually sloping surface extending some distance back of ordinary high-water line the storm waves had their energy gradually abstracted as they moved inland and were unable to exert any force capable of doing serious damage. On the other hand, it was most noticeable that wherever the land rose more or less steeply from the ordinary high-water line, or where there was a ridge or cliff which the waves were able to hit with considerable force, large masses of material were torn out.

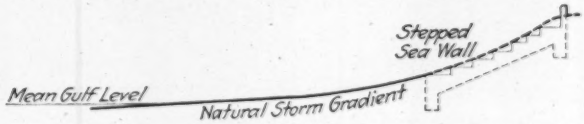

FIG. 11

FIG. 11. PROPER LOCATION OF SEA WALL

During storms, material in suspension and floating débris greatly assist the waves in their work of erosion. Stones, pieces of timber, etc., are hurled by the waves with great force against the shore or cliff and materially assist in the work of disintegration.

It may be stated as a general rule that on any coast where there is a considerable range of tide the foreshore has its natural inclination of repose, and it is undoubtedly equally true that the storm foreshore also has a natural inclination of repose, the gradient depending on the height of the storm tide, the height of waves, etc. Wherever, therefore, the gradient was too steep or there was a steep bank, the hurricane employed its energy in carving out a natural storm gradient; and in places where the gradient was too flat—as was the case in places where the waves broke over the coast road—the tendency was for material to be deposited (see Fig. 1).

Although a small amount of material eroded by direct wave impact was deposited on the road to build up the gradient (Fig. 1), by far the greater part of it was transported to the sea bed and permanently lost to the land. The strong onshore winds which blow during hurricanes pile up the water on the land margin, and would pile it up still higher but for the fact that this action is in part compensated for by an undertow seaward. Material stirred into suspension by wave action is thus transported to the bed of the Sound and permanently lost to the land. When the water subsides after the storm,

large quantities of material in suspension are also moved away and when the storm ceases are deposited in quiet water.

On the north side of the railway trestle at Bay St. Louis the reinforced-concrete vertical wall recently constructed successfully withstood the storm, while on the south side it was demolished. That this part of the wall was destroyed was no doubt partly due to the fact that it had not been backed up. It was, however, subjected to the full force of the storm and would in the writer's opinion have been badly damaged even if it had been backed up, a vertical wall being entirely unsuitable for such a situation.

It was also noticed that in many places between Biloxi and Waveland drainage water from the land, flowing across the storm foreshore, and seepage through the sandy soil increased the amount of erosion. Where a stream of water had cut a gully across the foreshore, material was moved in by oblique waves from the neighboring shore to fill in the hollow. This material was in turn moved away to the bed of the Gulf by the seaward flowing stream of water.

The hurricanes usually come from a southeasterly direction, and the waves formed thereby do not strike the shore at right angles to the main direction of the coastline but obliquely, and such oblique waves cause littoral drift (the alongshore movement of material) to take place. Owing to the inequality in the amount of shelter afforded to the coast by the outlying islands, to projections into the Sound—such as at Gulfport harbor pier—and to the varying contour of the coastline, the amount of such drift is not everywhere the same, and as a result localized erosion takes place.

On the Mississippi coast it is impossible to build up the storm foreshore to a natural inclination of repose and prevent further loss of material by constructing groins, as is successfully done on exposed coasts and where the range of tide is much greater. There is no supply of littoral drift on the Mississippi coast except the material moved alongshore during storms. In some places it might be possible to collect material during the storms, but it would be at the expense of the neighboring shore. As it is impracticable to protect the coast by "active defenses," it is necessary to adopt "passive" measures; that is, the object of the work must be to hold the material already there and to prevent further losses. This can undoubtedly be accomplished at a moderate cost by a sea wall, or facing to the upper part of the storm foreshore, thus substituting for the sand a durable material. In places where there is a tendency toward erosion by littoral drift, short groins may be built from the toe of the concrete work out to ordinary low-water line for the purpose of preventing the wall being undermined by alongshore movement of material already there.

The investigations of the writer seem to show conclusively that the storm waves tend to cut out a gradient of repose up which the waves will harmlessly roll, their energy being gradually abstracted by friction on the bottom. If instead of the natural gradient we have a vertical cliff or a sea wall halfway up the natural gradient, as shown in Fig. 10, it is obvious that this obstruction will be reached by the waves before their energy is abstracted; they will hit the obstruction and their impact will tend to destroy it. It is therefore obvious that it is a bad policy to construct on the foreshore a vertical sea wall, as not only would it have to be made very strong successfully to withstand the blows of the waves, but the rebound therefrom will scour out material from the front of the wall and tend to undermine it.

As has already been noted, little erosion took place during the last hurricane in places where there was an approximately natural sloping gradient. If the storm foreshore in such places had been covered with a thick matting of vegetation there would have been practically no erosion. It is impossible, however, to maintain such a covering of vegetation, as in the case of a zone which is occasionally flooded with salt water the conditions are not good for land plants; and if the shore is bare, material will be washed away by the undertow with every storm. The gradient will also be altered somewhat according to the height of storm tide, waves, etc., of each storm.

If, however, a gradually sloping sea wall is built to form a continuation of the natural storm gradient (Fig. 11), protection will be obtained, and such a structure will not be subjected to the blows of waves which a vertical wall would have to withstand. A stepped wall has advantages over a vertical sea wall, as the velocity of the uprush of the waves is considerably checked and the backwash, instead of flowing down with gradually accelerated velocity, has its velocity diminished as it pours from step to step. In places where there is a tendency for material to be scoured out from the lower part of storm foreshore owing to inequalities in the amount of littoral drift or other causes, it can be prevented by building low groins from the wall to low-water line of ordinary tides.

Immediate Protection Necessary

It has already been pointed out that the outlying islands shelter the Mississippi coast. It is therefore important that in the event of their being rapidly eroded and the possibility of their being washed away, it would be advisable to take steps to prevent their destruction. While there is some evidence of erosion of the seaward faces, there is also evidence of accretion at the landward faces, and there is no indication that they will be demolished within the next century. It would, however, be very desirable to have an accurate survey made from time to time, so that, if found necessary, steps could be taken later on to prevent further erosion of their sea faces.

The problem of protecting the coast from storm erosion is one of vital importance to the inhabitants of the coast towns of Mississippi. Not only is it impossible to maintain a road along the water front without protection works, but the property values have decreased in consequence of the liability to serious erosion. The towns are unlikely to develop as they should do if erosion continues, and a large expenditure is incurred after every storm in clearing up débris, repairing the road, sidewalks, etc. In fact, it may be stated that the prosperity and development of the Mississippi coast are dependent on protection being obtained against storm damages.

While the writer is of the opinion that the Mississippi coast can now be permanently protected at a moderate cost, there is little doubt that any serious delay in starting the work would very materially increase the cost and that if another hurricane attacked the coast before the work was carried out, the cost of subsequently building protection works sufficiently far seaward to enable a road to be maintained in front of the existing houses would be very expensive.

Making Concrete Tight; Tacoma and Seattle Water-Works

By C. E. Fowler*

SYNOPSIS—At Tacoma, repairing a leaky reservoir lining, with leakage precautions at the joints only; waterproofing the concrete and giving particular attention to the joints at another reservoir; waterproofing concrete for a settling well, an 85-in. reinforced-concrete conduit and liquid-chlorine-treatment tanks. At Seattle the concrete slabs of two reservoirs were not waterproofed, but the joints were asphalted and were supported on concrete ribs. Subsequent leakage was stopped by replacing some of the asphalt with a harder grade of material; some joints were repoured with lead.

The leakage in the Alaska St. distributing reservoir in Tacoma, Wash., recently became so serious that extensive repairs had to be made. The reservoir was originally built in 1895 with a capacity of 3,500,000 gal., but in 1908 it was enlarged by the addition of another section with a capacity of 7,500,000 gal., leaving a dividing wall between, making the whole reservoir about 200x300 ft. in plan and 20 ft. deep.

This new part, where the leakage occurred, was lined with concrete slabs approximately 25 ft. square and 6 in. thick, laid directly on the ground. The joints between the slabs averaged about 5/8 in. thick and had straight sides. The joints were not calked and were filled with tar and pitch of ordinary quality. Part of the leakage occurred through these joints, but a great part, which was so bad as to wash out the dirt underneath, was through defective slabs.

The superintendent of the water department, P. S. Savidge, recommended that the defective concrete be replaced and membrane waterproofing used, at a total cost of $7,500, but the City Commission ordered it repaired at a cost of about $2,000.

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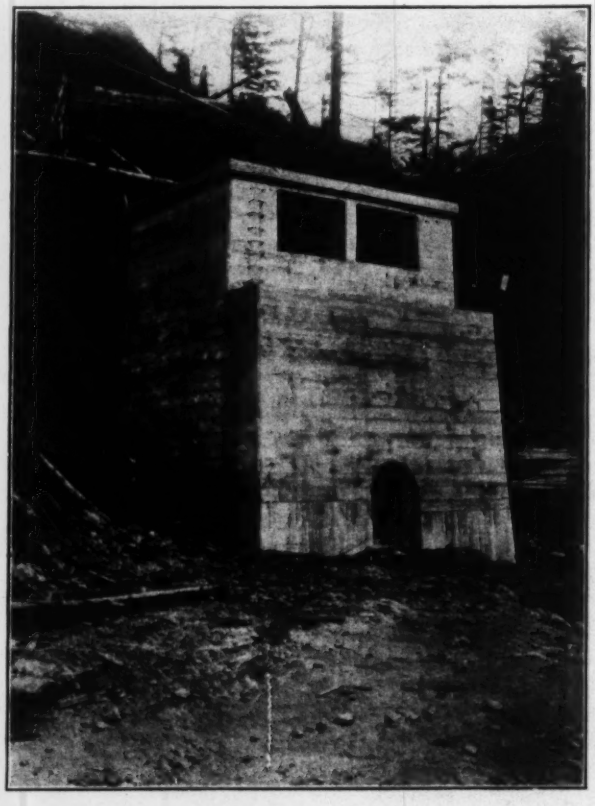


FIG. 1. SETTLING WELL AND BRIDGE ABUTMENT

FIG. 2. PORTION OF 85-IN. REINFORCED-CONCRETE PIPE, TACOMA WATER-WORKS

The defective slabs were removed, and some of them were found to have a thickness of only 2 in.! Four lines of 6-in. drain tile were put in across the reservoir, at a minimum depth of 18 in. The tile were laid on a 2x4-in. timber, the trenches backfilled with gravel and the four lines connected up to empty into a sump.

The new concrete slabs were laid and all the joints calked with oakum and poured with S grade of Floatine. Over the joints strips of burlap 10 in. wide have been laid in Floatine and painted over with two coats of asphaltum. These repairs have been carefully executed and the leakage has practically stopped.

The McMillan storage reservoir of the Tacoma Green River gravity water system is located about 18 mi. from Tacoma and is 350 ft. wide by 1,390 ft. long, with a central dividing wall.

The slabs in this reservoir were 6 in. thick and had joints 1/4 in. at the bottom and 3/4 in. at the top. These joints were supported on ribs 6 in. thick and 8 in. wide, with a layer of tar paper on top. The joints were then filled with refined asphaltum, specified to be pliable between freezing temperatures and 200° F., and not sticky at 120° F. This reservoir has not leaked since it was built in 1911, but the slabs were all waterproofed by adding 10% of hydrate of lime.

Three other pieces of work which were constructed on this system by waterproofing the concrete are worthy of notice, one being a settling well, which also acted as a

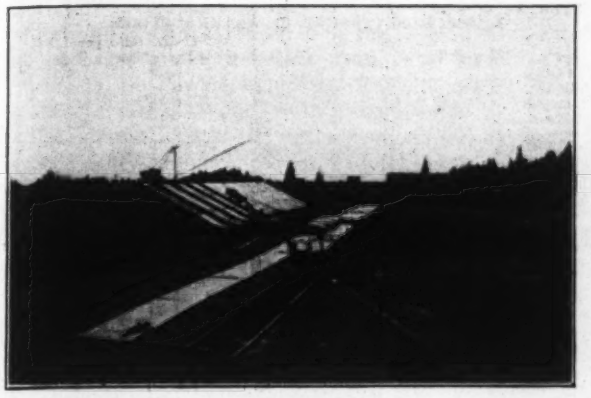


FIG. 3. PLACING BOTTOM IN GREEN LAKE RESERVOIR

bridge abutment (Fig. 1). This abutment was waterproofed by using 8% of hydrate of lime and has not leaked.

The 85-in. reinforced-concrete pipe between the tunnels at the headworks was not waterproofed further than to allow 5% of clay to be used in the sand and gravel making the concrete, and this has not leaked through the 12-in. walls (Fig. 2). The reinforcement was triangular mesh, lapped between sections, alternate sections being placed and the others filled in two days later. While fine hair cracks appeared at the junction of sections, nothing more than a slight seepage occurred. Approximately every 200 ft. telescopic metal expansion rings were introduced, packed with oakum and red lead, and no trouble occurred by leakage.

When the Green River system was completed the water was somewhat impure and a chlorine gas plant, manufactured by the Electro Bleaching Gas Co., was installed, using a tank 11 ft. in diameter and of 5,000 gal. capacity. This tank was built with Hyrib reinforcing, the sides being 3 in. thick and the base 6 in. thick. The sides were of plastered construction, 1 in. inside and 2 in. outside, and 3% of Medusa compound was used, resulting in a perfectly tight tank.

The two Green Lake reservoirs in Seattle, one of 65,000,000 and the other of 75,000,000 gal. capacity, were concrete lined by the writer from plans by R. H. Thompson, then city engineer. The 12x32-ft. slabs (Fig. 3) had a 1 to 8 concrete base and a 1 to 1½ mortar top, the base being from 6 to 8 in. thick and the top 1 in. thick. The joints were ⅜ in. wide at the bottom and ⅝ in. wide at the top, and were formed by a wedge-shaped board form soaked in oil. Underneath the joint was a rib 4 in. thick by 8 in. wide, with an asphalt-saturated wool-felt strip on top. These joints were poured with a special grade of asphalt of the Obispo brand, which met practically the same specified requirements as already given for the McMillan reservoir.

When water was turned in, this asphalt proved to be too soft. Serious leakage occurred and a large part of the filler was melted out and replaced by a harder grade of asphalt, which had originally been recommended by the asphalt company. Some of the joints were repoured with lead. Since these repairs were made no serious leakage has occurred. No waterproofing was used in the slabs and even the Sylvester alum wash which had been specified was not used.

Water-Supplies and Health in Massachusetts

By Arthur L. Gammage*

The relation between the character of public water-supplies and health is perhaps more readily studied in Massachusetts than in any other American state because of the long series of water analyses and the mortality statistics that are available for the cities and towns of the state. Moreover, the waters of Massachusetts show a wide variation in mineral and organic contents, and there is also a considerable variation in local death rates. From a somewhat extended study of the water analyses and the mortality statistics of the commonwealth the author has chosen for presentation here some highly interesting data on the relation between hardness and color and public health, the latter as reflected in the typhoid and general death rates. The data are for the ten years 1904 to 1913 and are presented separately for ground waters and for surface waters.

Relation Between Water Hardness and Health

It has been a much-disputed question whether a hard water or a soft water is the more beneficial to health. Various English, French and Austrian commissions have given opinions, some one way, some another. The general consensus of opinion today seems to be that in similar class towns and cities, having like principal sanitary conditions, the death rate is not raised or lowered by the softness or hardness of the water.

In Massachusetts the hardness in water ranges from 4 to 150 parts per 1,000,000. The study of this relationship has been undertaken for hard, medium and soft waters, taking the medium waters to equal in hardness the average hardness for each group of the two studies—ground and surface waters. The results of this study are summarized in Table 1.

TABLE 1. RELATION BETWEEN WATER HARDNESS, TYPHOID AND TOTAL DEATH RATES IN MASSACHUSETTS

Ground Waters—34 Cities and Towns	Average Hardness, Parts per 1,000,000	Death Rates per 1,000 Typhoid	Total
Softest	17	0.08	14.18
Medium	29	0.14	15.71
Hardest	71	0.11	14.12
Surface Waters—39 Cities and Towns			
Softest	5.7	0.115	14.99
Medium	17	0.10	13.85
Hardest	41	0.14	14.98

Neither in the individual results nor in the group results is there enough consistency to say that hard waters are more destructive of life than soft waters.

Color of Waters and Health in Massachusetts

In the groupings to show by contrast the effect of low colored waters and low typhoid on total death rates, the different waters are given in the order of ground waters, metropolitan waters and surface waters. The metropolitan surface waters are supplied to the suburbs of Boston as well as to the city itself, and special care in many directions has been taken to give this district a safe water and one protected to the utmost by storage and sanitary regulations. The color records are considered fairly representative for the period covered, and as in New England turbidity or suspended matter generally in water is small, color may be taken to represent æsthetic appearance, aside from taste, and sometimes including taste.

*With Robert Spurr Weston, 14 Beacon St., Boston, Mass.

TABLE 2. COLOR OF GROUND WATERS AND TYPHOID AND GENERAL DEATH RATES IN MASSACHUSETTS

City or Town	Color	Death Rate per 1,000 Typhoid	Total
Newburyport	20	0.33	18.94
Lowell	24	0.13	18.77
Hingham	19	0.10	17.72
Grafton	18	0.14	17.45
Fairhaven	39	0.05	17.31
Amesbury	20	0.22	16.95
Milford	27	0.20	16.59
Marblehead	24	0.06	16.58
Middleboro	27	0.09	16.35
Needham	2	0.00	16.35
Methuen	24	0.24	16.07
Natick	0	0.13	15.84
Chelmsford	15	0.10	15.72
Framingham	8	0.13	15.61
Mansfield	0	0.12	15.08
Winchendon	11	0.19	14.92
Braintree	13	0.11	14.89
Woburn	2	0.07	14.86
Dedham	4	0.03	14.72
Easton	0	0.08	14.62
Webster	4	0.07	14.34
Reading	26	0.09	13.94
Franklin	2	0.02	13.25
Adams	2	0.19	13.21
South Hadley	18	0.06	13.18
North Attleboro	0	0.07	12.96
Monson	0	0.10	12.78
Attleboro	4	0.06	12.62
Westboro	9	0.06	12.07
Norwood	15	0.07	11.09
Bridgewater	21	0.01	10.96
Walpole	0	0.00	10.75
Wellesley	0	0.02	10.04
Average		0.12	16.16
		Below 0.12	14.54
	Less than 22		14.63
	Less than 22	Below 0.12	13.66
	Less than 10		13.88
	Less than 10	Below 0.12	13.49

TABLE 3. COLOR, TYPHOID AND TOTAL DEATH RATES IN THREE GROUND-WATER-SUPPLY CITIES

	Color	Death Rate per 1,000 Typhoid	Total
Brookline	21	0.05	11.33
Newton	9	0.06	11.75
Waltham	11	0.19	13.18
Average		0.10	12.02

Average of places below average typhoid death rate, 11.44.

TABLE 4. TYPHOID AND GENERAL DEATH RATES FOR MASSACHUSETTS METROPOLITAN CITIES

City or Town	Death Rate per 1,000 Typhoid	Total
Stoneham	0.08	17.81
Boston	0.15	15.83
Arlington	0.10	14.70
Swampscott	0.06	14.57
Lexington	0.06	14.39
Revere	0.11	13.80
Chelsea	0.16	13.78
Somerville	0.11	13.15
Melrose	0.08	13.05
Malden	0.12	12.75
Winthrop	0.10	12.47
Quincy	0.07	12.39
Medford	0.07	12.07
Everett	0.10	11.84
Milton	0.07	11.25
Watertown	0.04	10.54
Average	0.11	12.94
Less than	0.11	12.59

In the metropolitan zone (Table 3), although not included in the metropolitan water district, are three ground-water-supply cities or towns which are comparable in population, geographical position and industries with the metropolitan suburban cities and towns, rather than with the ground waters or surface waters scattered all over the state.

Complete records of the quality of waters supplied to the different metropolitan cities are not available. Table 4, with color not given, shows that the suburbs of Boston have a lower average death rate than the city itself.

Nearly all unpurified surface waters have some odor. Although they are much improved by natural storage, still at times many ponds and reservoirs are deteriorated by the growth of organisms, which either in their growth or their decomposition give to the water objectionable odors and tastes. In general, the organic matter in a water will be less with less color, and hence there is less liable to be objectionable odor and taste in the lower colored waters. With the surface waters of Massachusetts

TABLE 5. COLOR, TYPHOID AND GENERAL DEATH RATES FOR MASSACHUSETTS SURFACE-WATER SUPPLIES

City or Town	Color	Death Rate per 1,000 Typhoid	Total
Fall River	26	0.14	18.83
Holyoke	24	0.10	18.01
Montague	9	0.14	17.90
Hingham	26	0.10	17.72
Salem	34	0.17	17.37
New Bedford	38	0.19	17.17
Ipswich	29	0.29	17.01
Plymouth	4	0.17	16.96
Milford	27	0.20	16.59
Chicopee	34	0.06	16.48
Pittsfield	26	0.21	16.31
Athol	41	0.11	16.22
Weymouth	56	0.07	16.16
Lawrence	34	0.19	16.02
Amherst	32	0.25	15.65
Abington	15	0.12	15.61
Palmer	29	0.09	15.57
Springfield	26	0.21	15.49
Worcester	24	0.09	15.36
Haverhill	28	0.14	15.31
Westfield	33	0.16	15.18
Taunton	26	0.16	15.13
Cambridge	29	0.10	15.09
Andover	20	0.15	15.08
Peabody	22	0.19	14.95
Spencer	13	0.08	14.67
Northbridge	31	0.11	14.62
Rockland	15	0.12	14.61
North Adams	20	0.20	14.49
Great Barrington	13	0.08	14.44
Gardner	15	0.12	14.42
Greenfield	11	0.07	14.41
Leominster	32	0.09	14.37
Gloucester	35	0.10	14.30
Beverly	34	0.19	14.22
Southbridge	39	0.13	14.11
Easthampton	20	0.08	13.96
Marlboro	31	0.07	13.91
Wakefield	26	0.10	13.56
Fitchburg	20	0.12	13.50
West Springfield	20	0.04	13.39
Northampton	23	0.10	13.32
Adams	2	0.19	13.21
North Andover	21	0.05	13.20
South Hadley	18	0.06	13.18
Lynn	48	0.15	13.16
Maynard	18	0.08	13.04
Danvers	48	0.12	12.70
Whitman	18	0.02	12.09
Brockton	18	0.10	11.79
Hudson	26	0.07	11.67
Norwood	20	0.07	11.09
Winchester	20	0.00	10.54
Concord	8	0.06	10.45
Average		0.14	15.41
		Less than 0.14	14.61
	Less than 22		13.76
	Less than 22	Less than 0.14	13.11

(see Table 5), as well as the ground waters, the color will represent to a good degree of accuracy the agreeable acceptance of that water by the consuming public.

The surface waters of Massachusetts have not reached a state of purification by storage or other means where more than one town could be put in a class of waters of color less than 10 parts per 1,000,000 and a typhoid rate of under 0.14 per 1,000.

Dividing the whole number of places previously using ground waters, metropolitan waters or surface waters into two groups—one having a death rate less than 15.87, the average for the whole state for the 10-yr. period used, and the other a death rate of over 15.87 per 1,000—we find about two-thirds of the waters having a color of less than 22 have a death rate below 15.87, while about two-thirds of the cities the death rate of which is over 15.87 have a color of over 22.

In general, a color above 22 on the platinum scale begins to be noticeable to the consumer, and this point has been taken as the separating line to determine the effect of appearance of water on the death rate, as well as to determine whether the good-appearing waters and their corresponding cities and towns of the state are the best protected from a sanitary standpoint, taking the typhoid death rate over a period of 10 yr. as the indicator.

From a different standpoint, that of the high-death-rate cities and low-death-rate cities, which are those whose average for 10 yr. is below the state average, a critical examination has been made to find whether good appearance

held sway in the contest for low death rates or whether sanitary protection as measured by the typhoid death rate was sufficient to determine low death rates for places so improving their water-supplies. Table 2 shows these figures for places supplied with ground water.

The ground waters and surface waters of the lowest typhoid death rate have the lowest total death rates, and the difference is at least several times the average typhoid death rate for that class of waters.

In the case of the metropolitan waters, the towns and cities of low average typhoid death rate have a lower total death rate than the average. However, the metropolitan authorities would strenuously object to rating the sanitary quality of the water in the different cities by the typhoid death rate, and I would rather attribute it to collective and individual sanitation than accident when it includes about one-half the metropolitan suburban population in the low typhoid death rates.

Even more remarkable than the lower death rates with lower typhoid rates is the observation of the lower death rate with lower colored waters, and especially with the lower colored waters of the low typhoid death rates. This condition exists in the case of both surface waters and ground waters and in group combination of the two classes of waters.

It must be remembered that comparatively few Massachusetts cities have installed water-purification plants and that both mechanical filters and water disinfection by hypochlorite or by liquid chlorine treatment are notable for their absence.

Financing County Roadbuilding in Illinois

Vermilion County, Illinois, voted $1,500,000 of bonds at the election in November, 1914, for 174 mi. of paved roads to be constructed during the years 1916 and 1917. According to information furnished by P. C. McArdle, Superintending Engineer (Assistant Chief State Highway Engineer), Danville, Ill., this system of country highways reaches every city and village in the county. It comprises two main roads north and south and five roads east and west (see accompanying map).

For construction purposes the system has been divided into nine divisions of approximately 19 mi. each. It is the purpose of the county to let all the work by contract to the lowest responsible bidder early in the spring of 1916, after the supreme court decision on the validity of the bonds, which is expected at the December term of court. The circuit court of the county has already sustained the issue.

The county road-improvement committee at Danville, Ill., through its Superintending Engineer, P. C. McArdle, is preparing plans, specifications and estimates of cost. These plans should be in readiness by about Feb. 1, 1916. The designs and specifications follow almost exactly those of the Illinois State Highway Department. Included in these contracts will be grading, drainage, small culverts, farm entrances and a pavement 10 ft. wide of brick or concrete, with 3-ft. gravel or macadam shoulders.

The bonds bear interest at 4% and are issued serially; $75,000 worth are retired each year. The actual amounts, including interest, the cost per $100 of assessed valuation and the approximate cost per acre on farm lands, are shown in the table.

STATISTICS OF PROPOSED COUNTY BOND ISSUE, VERMILION COUNTY, ILLINOIS

Year of Payment	Payments of Principal and Interest as Fixed by Supervisors	Approximate Direct Tax Required on Each $100 of 1913 Assessed Valuation	Approximate Cost per Acre on Farm Lands (Average Assessed Value per Acre, $30.63)
1	$95,000	$0.26¼	$0.08
2	112,000	.30⅞	.09½
3	129,000	.35½	.10⅞
4	126,000	.34¾	.10⅝
5	123,000	.34	.10½
6	120,000	.33	.10⅛
7	117,000	.32¼	.09⅞
8	114,000	.31½	.09⅝
9	111,000	.30⅝	.09½
10	108,000	.29¾	.09⅛
11	105,000	.29	.08⅞
12	102,000	.28⅛	.08⅝
13	99,000	.27¼	.08½
14	96,000	.26½	.08⅛
15	93,000	.25⅝	.07⅞
16	90,000	.24⅞	.07⅝
17	87,000	.24	.07½
18	84,000	.23⅛	.07⅛
19	81,000	.22¼	.06⅞
20	78,000	.21½	.06⅝
General average per year	$103,500	$0.28½	$0.08¾

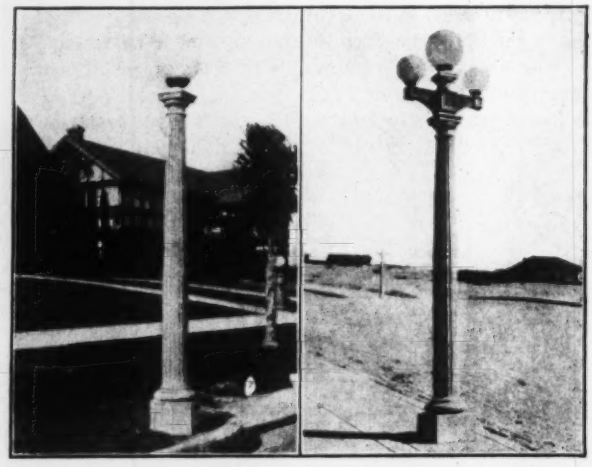
MAP OF VERMILION COUNTY, ILL., SHOWING PROPOSED ROAD SYSTEM

By reference to the map it will be noted that the county is traversed by eight railroads (four east and west and four north and south) and by one interurban electric line. The roads to be improved are divided with regard to present railroad sidings into divisions, so that the average haul does not exceed 3 mi. The county is comparatively level, and contractors' hauling by industrial railways should prove eminently satisfactory, except in a few instances.

Concrete Lighting Standards Made Attractive

By L. W. R. Allison*

A new and attractive design of reinforced-concrete lighting standards is being used in many of the southern California cities and towns, good examples of which are shown in the accompanying views. The standard is made by centrifugal molding, and in completed form closely resembles cut and polished stone or marble. The surface



FIGS. 1 AND 2. CONCRETE LAMP STANDARDS

is hard, smooth and impervious to moisture. This column is produced in designs patterned after the classic types of Greek and Roman architecture. A single-lamp standard of Doric column model, with octagonal base, is illustrated in Fig. 1, and a three-light standard with the same shaft on a square base is shown in Fig. 2. These reinforced-concrete posts are cast in three distinct parts—shaft, base and cap. A sectional view of a typical lighting standard is shown in Fig. 3, with base, shaft and capital erected in place and securely anchored to the concrete foundation by twisted steel reinforcing rods. A line of sherardized conduit is run through the hollow center from top to bottom and provision made for a cutout box. The size of the cored center varies for different types of posts.

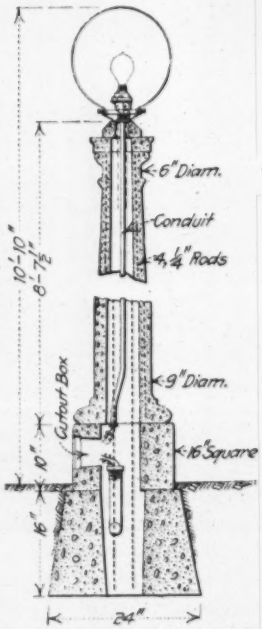


FIG. 3. COLUMN SECTION

In making these standards a wooden or metal mold of desired dimensions and exterior outline is made in two or more parts. When steel reinforcement is required, this is built up and placed in the mold, properly supported from the walls on radial lines. The sections of the mold are securely fastened and the necessary mixture of gravel, sand and cement is poured in at the end. The mold with contents is then rotated about its axis at such a speed as will hold the wet concrete against the walls. This depends on the diameter. In about 30 min. the preliminary set is attained and the mold and column are placed aside for 24 hr. Final curing is done out of the mold in the open air, the concrete being kept well moistened.

While at first it might seem that the larger particles of the aggregate would be forced to the outside and cause a rough surface, actual work shows that all voids are filled, securing a hard and smooth exterior, such as cannot be obtained by tamping. The similarity of the finished surface to polished stone has resulted in the local trade name "marbelite." A recent test for absorption as compared with well-tamped concrete of like mixture showed that the surface of the whirled concrete absorbed less than one-half the moisture taken up by the tamped product in the same period of time.

This centrifugal process of manufacture is effectively employed for a variety of concrete products, such as ornamental columns, poles, piles, etc. The attractive open-shelter railway station, shown in Fig. 4, as erected at one of the Los Angeles beach resorts, on the line of the Pacific Electric Ry., has posts made like the lighting standards described.

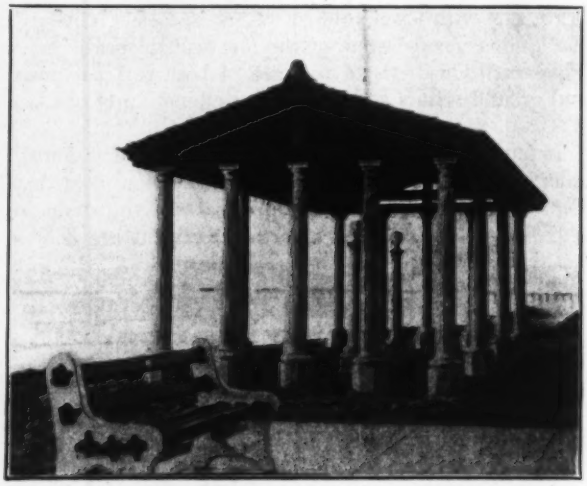


FIG. 4. RAILWAY SHELTER WITH CENTRIFUGALLY MOLDED POSTS

*170 Roseville Ave., Newark, N. J.

Progress of Santa Barbara Water-Supply Project

By K. Q. Volk*

A possible serious bar to the water-supply project of Santa Barbara, Calif., has been removed in an unexpected way. California has an obnoxious riparian law which in the past has substantially interfered with the development of the state. Under it, riparian owners on a stream can object to diversions of water at points on the stream above them. The California courts in some instances have ruled that no water whatever could be taken out of a drainage basin, but of late the California Supreme Court has shown a tendency to relieve the situation and has given two decisions to the effect that waters may be

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diverted out of drainage basins for beneficial uses, provided there is no substantial damage to lower owners.

In developing an additional water-supply for the City of Santa Barbara it became necessary to seek it from a distant mountain drainage basin. A tunnel 19,600 ft. in length has been driven through the Coast Range, which is known as the Santa Ynez Mountains, to the Santa Ynez River. This river, above the upper portal of the tunnel, drains 208 sq.mi. of rough mountain country and flows in a westerly direction, discharging into the Pacific Ocean 68 mi. west of Santa Barbara. The City of Santa Barbara is not in the drainage basin of the Santa Ynez River. It is a portion of the plan to erect a concrete dam 180 ft. high above bedrock and develop a storage capacity of 16,000 acre-ft. This reservoir will be filled by the winter flood waters, which would otherwise flow into the Pacific Ocean.

The lower riparian owners on the Santa Ynez sought to enjoin the City of Santa Barbara from continuing the construction of the dam which had been started and petitioned for the closing of the tunnel so that water could not be diverted to the city.

There were two principal plaintiffs against the city and approximately a dozen interveners, who also were objecting. The case came to trial on Oct. 7, 1915, at Santa Barbara and developed an amusing situation. Neither one of the plaintiffs appeared to press the suit, and all of the interveners expressed a willingness to accept judgment in accordance with the answer of the defendent City of Santa Barbara to the plaintiffs' complaint. This involved the diversion of an equivalent continuous flow of 13 cu.ft. per sec. of water from the reservoir site. It was conceded by all who appeared that Santa Barbara had the right to impound and divert flood waters, but it was contended that it did not have the right to divert the normal flow of the river.

The legal features of the case were handled by W. P. Butcher, City Attorney for Santa Barbara, assisted by George Gould and W. B. Matthews, of Los Angeles. The engineering offices of J. B. Lippincott, of Los Angeles, prepared the engineering data.

The case is important, as it indicates the changing opinion that has developed in California relative to riparian rights.

California Examination for Construction Engineer

The following problems and questions were submitted to candidates for the position of construction engineer for the State of California in an examination recently held at San Francisco:

Specifications for Construction (Time 3 hr.; no reference books allowed)—Select one of the most important pieces of engineering construction with which you have been identified and write complete specifications covering the materials and the incorporation into the work of the three principal items estimated for payment under the contract.

Conditions Determining Types of Construction (Time 4 hr.; no reference books allowed)—Select one of the most important pieces of engineering construction with which you have been connected during the past five years and write a description of the conditions governing the selection of the type of work built, describing briefly what that type was, illustrating by pencil drawings and demonstrating why this type was best adapted for the site and conditions of use. Any difficulties which arose during construction should be described, and suggestions should be made as to alternate designs which might have been applicable and economical.

Supervision of Construction (Time 3 hr.; no reference books allowed)—From memory of actual conditions write a complete monthly progress and cost report, addressed to a hypothetical superior officer, recounting in detail the progress made during a typical month on some piece of engineering construction with which you have been connected in a responsible capacity. A cost report should be incorporated as part of the monthly report, and should give in detail the cost of the various items entering into the contract, as well as giving the total number of men and teams, number of days worked and the supplies, materials and machinery used.

Materials of Construction (Time 4 hr.; hand books or reference books may be used; take one of the seven problems.)

Problem I—Make a design for a two-span wooden highway bridge, having a roadway 18 ft. wide in the clear and spanning a canal 40 ft. wide at top of banks and 10 ft. deep. Water in the canal is 6 ft. deep. A single-framed trestle bent is allowed in the middle of the stream, and wooden mudsills are permissible. The uniform live-load is 100 lb. per sq.ft., and maximum live-load is due to a 15-ton traction engine having two-thirds of its weight upon one axle, the distance between axles being 12 ft. Show all details with dimensions. Make bill of materials, together with estimate of cost of materials only, if lumber costs $26 per 1,000 ft., board measure, and nails $3.50 per 100 lb. delivered at the site of the work. Show computations.

Problem II—In building a large masonry dam, rectangular steel towers 50 ft. high and 25x50 ft. in plan were erected on the dam foundation for the purpose of each carrying two 10-ton capacity stiff-legged derricks having 50-ft. booms. Each derrick had its hoisting engine mounted on top of the tower. The total load to be provided for, both live and dead, is 40 tons. Design a tower with riveted connections, showing the dimensions of all main members, and give details of bracing, connections, etc. Show computations.

Problem III—A small city proposes to build a circular water-supply tank of reinforced concrete on top of a hill, where the foundations will be upon a firm gravel. Inside dimensions of the tank are to be 30 ft. diam. and to hold water 20 ft. deep. No roof will be required.

(a) State proportions of concrete for foundation and walls.
(b) Give all required computations.
(c) Sketch details of design with dimensions, and give sizes and spacing of the steel reinforcement required.
(d) Specify briefly the principal requirements governing the making and placing of the concrete.

Problem IV—A crossing of a single-track railway over a highway requires abutments of first-class granite ashler laid in cement mortar. Both the abutment foundations and the railway embankment are composed of a medium-fine grade of sand, and the former will always be wet. The embankment is 24 ft. high, 14 ft. wide on top and with 1½ on 1 side slopes. Maximum load on top of one abutment equals 100 tons. Sketch design for one abutment, showing:

(a) Details of foundation.
(b) Dimensions and arrangement of courses and widths of face joints.
(c) Bridge seat, assuming a through plate-girder bridge.

Problem V—A highway embankment crossing a watercourse has such a height that the maximum load, both live and dead, on the culvert may be considered uniformly distributed at the rate of 1,500 lb. per sq.ft. For this condition design a triple-arch, plain concrete culvert 100 ft. long, each arch to have a clear span of 18 ft. and a rise of 4 ft. Piers are to be 5 ft. in height from culvert floor to arch springing line. The maximum allowable pressure on the foundation is to be 3.5 tons per sq.ft.; maximum velocity of water in culvert, 6 ft. per sec.

(a) Show cross-section of culvert.
(b) Show end elevation of parapet, etc.
(c) Compute cost of the concrete alone if the latter costs $12 per cu.yd. in place.
(d) State proportions of concrete to be used and what precautions should be taken to secure good work.

Problem VI—Farm land worth $200 per acre, and located in river bottom subject to flooding, is to be protected from overflow by a levee which must resist a rise of 20 ft. in water level above the normal elevation. The river banks are covered with trees and brush, and fine sand and sediment are the only materials available for building the levees.

(a) Design a satisfactory levee, indicating all details.
(b) Specify in detail how it should be constructed and how it should be protected from erosion. The river channel at ordinary water stages is 600 ft. wide and is navigable for large craft.

Problem VII—Smithville is a farming center having a population of about 5,000. It is located 10 mi. from any railroad, the nearest station being at Jonesville (population 20,000). At present no good road exists between the two cities, but one is to be constructed, which when completed will be the principal outlet of Smithville.

Between the two cities there is a ridge about 2,000 ft. high, with precipitous sides, and there is a ravine 50 ft. deep and ¼ mi. wide. The stream at the bottom of the ravine drains about 4 mi. of hilly land and, at the site of the proposed road, has a fall of 5 ft. per 1,000.

Near Jonesville the soil is very sandy, but at Smithville there is a top soil of from 1 to 2 ft. of black loam underlaid by yellow clay. The ridge is of gravel, hardpan and ledge rock. The other features and conditions are the same as those usually encountered in the construction of a road.

(a) Outline briefly all steps necessary from the time the road is proposed until it has been thrown open to traffic.
(b) Draw an imaginary plan, scale 1 in. equals ½ mi., and a profile of appropriate scale to accompany the same. Give sketches of proposed structures. Draw also several typical sections showing present surface and proposed section and pavement.
(c) Dicuss briefly the type of construction, kinds and sizes of structures and why chosen.
(d) Write brief specifications for the work and for the materials to be used.
(e) Make a detailed estimate of the quantities and costs.

Field and Office

Moving a 30-In. Gas Main

By Raymond J. Van Wagner*

To use the open-cut method of construction for 2,000 ft. of the Lexington Ave. subway in Whitlock Ave., Borough of the Bronx, New York City, it was found necessary to change the location of 1,500 ft. of 30-in. gas main.

About 1,450 ft. of the whole 2,000 ft. of this main was on a curve of 1,200-ft. radius, and the remaining 550 ft. was on a tangent. The new location was approximately parallel to the old. To economize, as much of the old pipe as possible would have to be used; and as the service could

FIG. 1. A 450-FT. LENGTH OF GAS MAIN ROLLED INTO NEW LOCATION

be interrupted for only a limited period, the pipe to be re-used would have to be moved quickly.

It was finally decided to lay new pipe on the curved portion of the pipe line, and to roll the remaining pipe from the old location to the new. As there was a slight change of direction in the 550-ft. length to be moved, it was decided to roll the pipe in 450- and 100-ft. sections.

The new location was just outside of the neat line of the subway, and the regular excavation for the subway was widened to include the excavation for the new pipe line. At the same time the existing pipe line was uncovered. The subgrade for the new position of the pipe was graded, and bed blocks were set to line and grade. Pieces of 12x12-in. timber were then laid across the cut, one timber to every second length of pipe, and the pipe was notched at the desired breaking points.

After all new pipe was in position on the curve, two cables were placed around the 450-ft. length of old pipe, dividing it into three equal parts. These cables were anchored in position on the bank over the new location, passed around the pipe and back to blocks placed near the anchored end, then returned across the cut to other blocks. The hauling was done by fastening the ends of the lines to two locomotives on the tracks of an industrial railway parallel to the pipe line.

The gas was cut off and the pipe broken at the notched points. At a given signal both locomotives started pulling, and the pipe rolled over the timber supports to its new position. Fig. 1 shows the 400-ft. length immediately after rolling into position. The actual time of rolling was 25 sec. By repeating these operations the 100-ft. length was put in place in 30 sec. Fig. 2 shows the pipe at the start and Fig. 3 shows it rolling into place.

To allow clearance for the steam shovel and to allow for erection of steel, etc., the lower end of the pipe, which will rest on the subway roof when completed, was bypassed on overhead cables supported on two towers placed outside of the neat subway line.

The pipe was restored to service after a delay of only 6 hr., which was well within the time limit. Very little calking was required, as the joints held fast.

The work was done under the personal direction of John H. Hagerty, of Rodgers & Hagerty, contractors for this section of the subway work.

*Assistant Engineer, Public Service Commission, 1372 Zerega Ave., New York City.

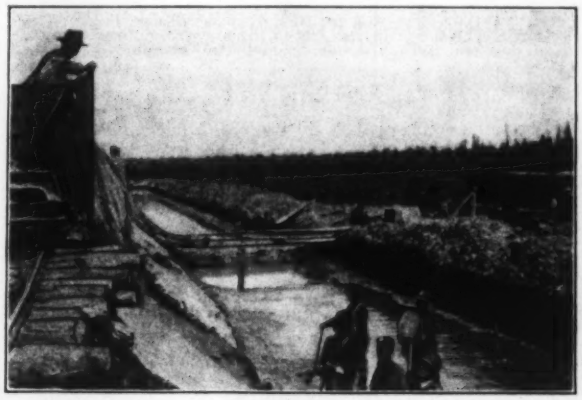
FIG. 2. CABLES PLACED FOR ROLLING 100-FT. SECTION

FIG. 3. ROLLING 100-FT. LENGTH OF GAS MAIN

Sand-Puddle Foundation for Heavy Aqueduct

A novel scheme was employed for obtaining firm bearing for the large concrete conduit now being constructed for the Greater Winnipeg Water District, Canada. The trench bottom at some points was too soft at the elevation of the invert to carry the conduit. In these places all the soft material was removed and an artificial bottom was prepared by flooding the trench with water to a depth of a foot or two and dumping sand or gravel into the trench. This material was cast or worked so that it settled into the water, so that the water level was maintained always higher than the top of the fill. These foundation fills in cuts are carried up a few inches higher than the required elevation; then the water is pumped or drained out of the trench in such a way that it passes down through the sand or gravel instead of flowing off over the surface.

This method has resulted in a bottom so tight and hard that the invert can be laid on it almost as soon as the water has drained out. In fact, the material was so tightly packed that it was necessary to use picks and mattocks to trim for receiving the invert. The accompanying view shows one of the soft-bottom trenches with the water standing in it and a load of gravel being dumped. The material for these foundation fills was obtained, for the most part, from the gravel plant of the water district and contained so much sand that had there not been this use for it the material would have had to be wasted.



DUMPING GRAVEL FOR TRENCH BOTTOM TO CARRY AQUEDUCT

Concrete Mixing and Placing, Ford Building, Buffalo

In the construction of the automobile assembling and sales building for the Ford Co. at Buffalo, N. Y., some interesting methods were used in the concrete work. The architect is Albert Kahn, of Detroit. The Turner Construction Co., of Buffalo, has the general contract. H. E. Plumer is the company's engineer and W. T. Baker is its superintendent.

The building is about 435x100 ft. in plan, four stories high, with a deep basement under one end. The first floor is at the street level (Main St.), and the basement floor is level with the depressed tracks of the New York Central R.R. The rock cut was widened to give space for spur tracks and a loading platform. The floors and roof are of flat-slab construction. The columns and their flaring capitals are octagonal, so that it was a simple matter to make the forms of wood, there being no curved surfaces. The walls are faced with brick and terra cotta on the outside.

The layout of the construction plant is shown in Fig. 1. The supply track, concrete mixer and concrete elevator

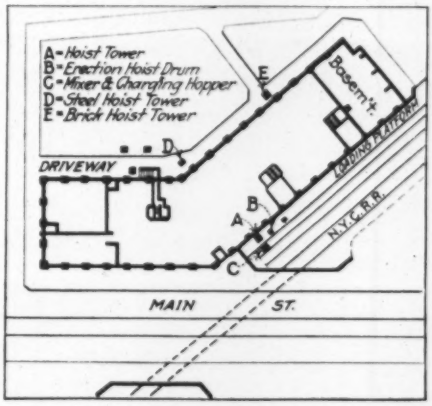


FIG. 1. PLAN OF CONSTRUCTION PLANT FOR THE FORD BUILDING AT BUFFALO, N. Y.

tower are at the lower (railway) level. On the other side of the building are three hoisting towers at the upper (street) level. One of these is for the reinforcing steel and the others are for the brick.

Mixing and Conveying Plant

Materials are delivered on cars and the cement is stored under the Main St. bridge. Sand and gravel are unloaded by hand into 1-yd. portable hoppers or bins standing beside the cars (Fig. 2). Thence the material is discharged by gravity into wheeled carts of 6 cu.ft. capacity for delivery to the stock pile or the mixer.

A ⅔-yd. mixer is used, set in a pit so that it can be charged by gravity from the carts at the track level. It delivers the concrete into a ¾-yd. self-dumping elevator bucket in a tower 90 ft. high, operated by a 40-hp. motor and friction hoist. This bucket discharges into a short chute at the floor or roof level as required, the concrete flowing to a hopper with a gate, from which it is delivered to the 6-ft. carts to be wheeled to the forms. The mixer and hoist are operated by a 40-hp. electric motor.

Floor Construction

In order to complete the building as rapidly as possible the forms for the floor were made in panels approximately 5x12 ft. When these panels are placed there is a loose board built in between each two form panels. After the floor has been concreted, and before any of the forms have been disturbed, a secondary set of shores is placed under these loose boards so that the floor is still properly supported after removal of the forms. These secondary shores are allowed to stand under the second floor until the roof has been concreted, and in no case are they removed in less than 24 to 28 days.

In order to give proper grade to the floors, strips of Norway pine are used, 2x6-in., dressed on four sides. These are supported on edge, so that the lower edge is level with the finished floor. They are supported by ½-in. eyebolts 18 in. long. The eye is 2 in. in diameter and fitted down against the upper edge of the strip. There is

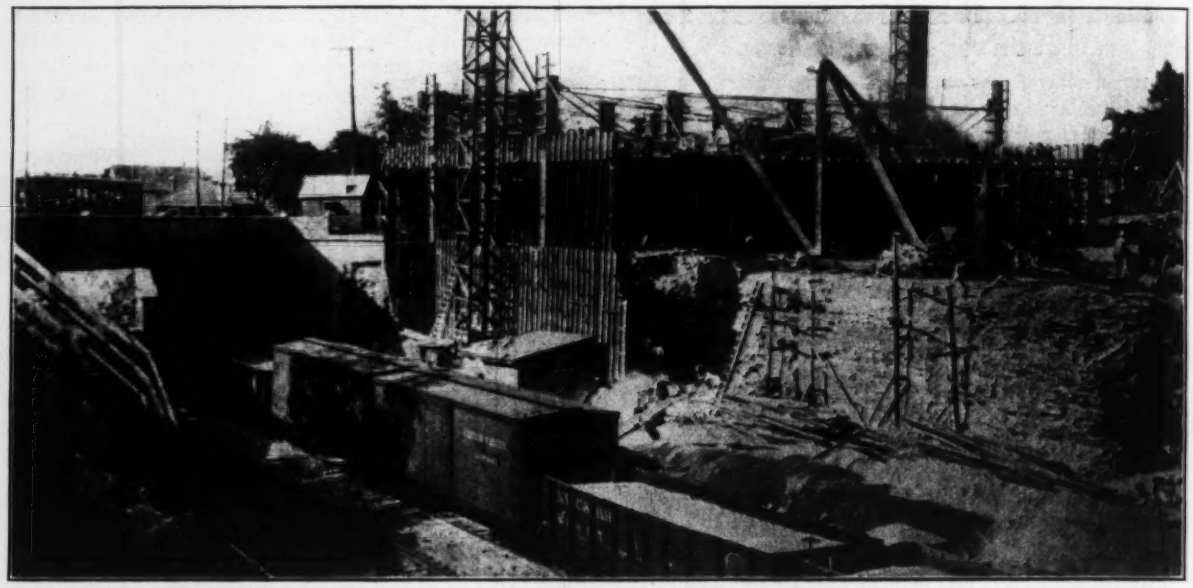


FIG. 2. CONCRETE SUPPLY AND MIXING PLANT

The cars are on the supply track, and materials are wheeled to a hopper discharging into a mixer below the ground level. At the right is the rock excavation for the basement. The tower at the left is for elevating the concrete. The other is for hoisting steel rods, being sheathed on one side, so that the rods will not catch in the bracing

a nut directly on the lower edge of the strip and two nuts on top of and underneath the floor forms. By loosening or tightening these two lower nuts the strip can be set to any height. These strips are set as soon as the steel is in place and are leveled with the aid of an instrument.

In order to grade the floor between the strips a 2x10-in. plank is notched on each end so that its bottom edge will be flush with the bottom edge of the 2x6-in. strip. After the floor has been set off with a straight-edge the nuts under the bottom of the floor form are removed and a hook inserted in the eye of the eyebolt to pull out these strips. This leaves only the bolt holes to fill up before floating the floor. After this floating, the floor hardener is applied and the floor finished in the usual manner.

Methods of Handling Steel

The steel bars for reinforcement vary in length from 6 to 60 ft., and it was desired to hoist these to the various floors with as little chance of bending as possible. It was decided to build a tower of such height that the long bars could be hoisted on end clear of the floor and lowered to the floor. For that reason the tower used for hoisting steel is approximately 125 ft. high. This hoist is operated by a 40-hp. motor and friction drum, which were later used for the second brick hoist.

The steel was hoisted for the entire job and placed on the various floors as soon as the first section of the building was up. This permitted the use of the steel laborers to good advantage at a time when progress is slow, while starting the second section, and also allowed the use of the hoisting drum as soon as work was ready for the brick on the second section. This tower is sheathed on one side with 1-in. sheathing to prevent the rods from catching on the braces.

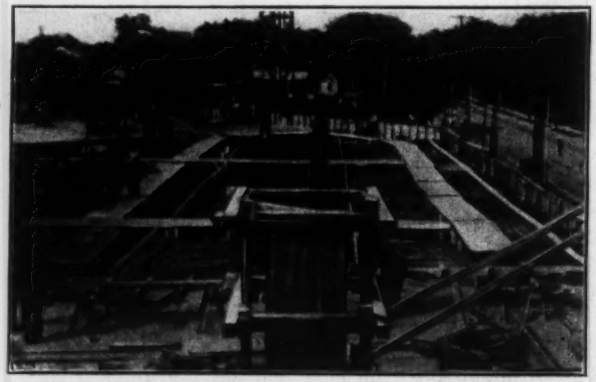


FIG. 3. CONCRETING THE FIRST FLOOR OF THE FORD BUILDING

The elevator tower is at the rear, with its bucket delivering concrete to wheeled carts which are operated on the wide runways

Force Employed

The force has averaged about as follows: Forty carpenters, 35 bricklayers, 8 cement finishers, 10 steel laborers, 25 carpenter helpers, 50 concrete laborers, 28 brick laborers and 25 general laborers. Each of these gangs is under the direct supervision of a foreman, and in the cases of the bricklayer and carpenter gangs the foreman has one assistant.

The carpenters are mostly men who have worked for the firm on similar work before. They work in pairs, a new man always being paired with an experienced man. The bricklayer gang is divided into three sections—the first to lay the terra cotta, the second to lay face brick and the third to lay common brick. About 50% of the concrete gang are men who have worked for the firm before. The remainder are the quicker and better class of general labor. The average is from 36 to 40 yd. of concrete per hour with this gang, with a record of 425 yd. in 9½ hr.

Right-Angle Offsets by standing on the survey line with arms extended so as to be in alignment, then looking directly to the front, quickly bringing both arms forward and sighting over the hands, will give points within 1.5 ft. in 60 ft. This figure is the average obtained in a large number of tests by W. W. Gruber, Cincinnati, Ohio. The opportunity for these tests was the need for using the method extensively for short offsets from a railway survey line to fences, creeks, roads, etc., where greater accuracy was not required.

Laying Wood-Stave Pipe to Replace Steel Pipe

Twenty-two years ago a wrought-iron penstock pipe supplying power water for the mill of the Flory Milling Co., Bangor, Penn., was laid in the channel of Martin's Creek, practically the whole length being exposed to the water. In its service since then the pipe rusted full of holes, and this summer its condition became so bad that immediate replacement was imperative. Cast-iron, sheet-iron and wood pipe were considered for the new pipe, and wood-stave pipe was adopted. A 36-in. pipe, 3,000 ft. long, is being put in. Most of it will be covered.

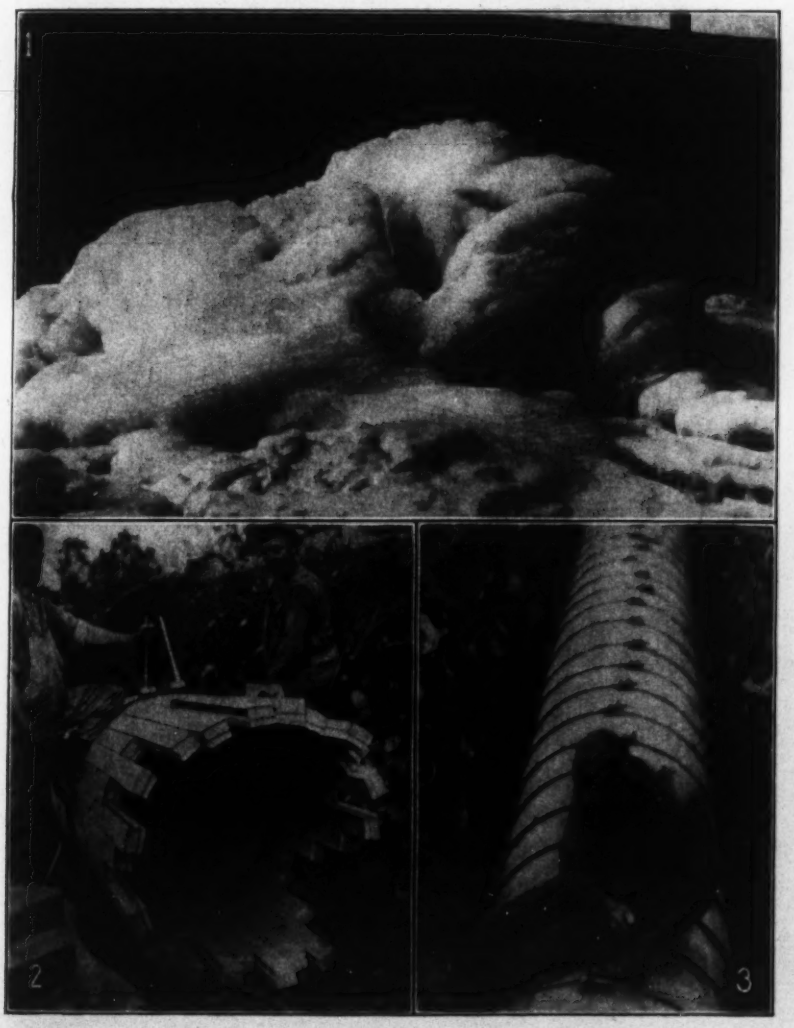
The 3-in. white-pine staves for the pipe, 4 in. wide, are milled by the Fitzgerald-Speer Co., of Pen Argyl, Penn. They are made of selected log run from West Virginia, grading about No. 2 barn and better. The inner and outer faces are milled to the radius of the pipe, so that an entirely smooth inner surface is obtained. The side faces are tongued and grooved. The ends are cut square and have a saw cut 1 in. deep parallel to the outer face of the stave, in which a ⅛-in. iron tongue plate is placed in assembling the pipe.

Staves are delivered daily at the trench fresh from the mill, as it was found that when left exposed over night they absorbed a certain amount of moisture and were harder to work.

The pipe is built right in the ditch. It is bedded on the earth, without concrete supports, and after completion it is covered. The staves are furnished in various lengths from 2 ft. up; joints are staggered throughout, and at the same time the odd lengths give perfect freedom to cut out any pieces of unsatisfactory quality. The banding is ⅝-in. round iron, with both ends threaded, the nuts engaging a cast lug. The bands are spaced about 12 in. apart. They are painted one coat of asphalt before applying.

The labor of building the pipe is six men and boys at a combined labor cost of about $15 a day, who build and lay complete 100 ft. of pipe per day. This makes the cost of laying about 15c. per ft.

E. A. Speer, of the Fitzgerald-Speer Co., worked out the design and manner of building the pipe. Milton Flory, president of the Flory Milling Co., is superintending the work personally.



FIGS. 1 TO 3. WOOD-STAVE PIPE WORK IN BANGOR, PENN.
Fig. 1—The 22-yr.-old iron pipe in winter; note stream of water spouting through the ice. Fig. 2—Assembling 36-in. wood-stave pipe in trench. Fig. 3—Tightening bands

Gasoline Dinkeys Haul Concrete

The practice of using gasoline dinkeys for hauling cars of concrete has become widespread. It is successfully employed on at least three construction jobs now under way in the United States and Canada and was used in placing the concrete piers of the Sciotoville bridge of the Chesapeake & Ohio Northern Ry. These dinkeys are used in the construction of the large concrete conduit of the Greater Winnipeg water-supply, on the Harrisburg (Penn.) bridge of the Cumberland Valley R.R. and on the Little Scioto viaduct of the Chesapeake & Ohio Northern Ry.

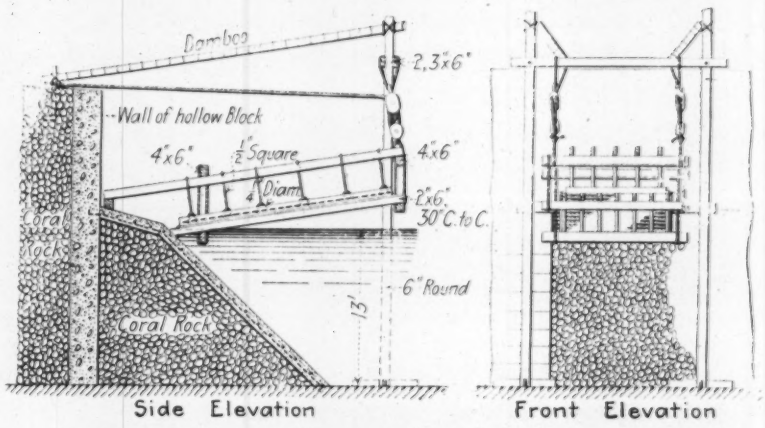
Reports from these jobs show special satisfaction with dinkey transportation of concrete. The method is fast and no report of segregation of the materials has come from any quarter. In fact, James H. Fuertes, consulting engineer of the Greater Winnipeg Water District, expressly states that there is no segregation of the materials in the cars and that no difficulties have been encountered with this method of transportation. The concrete on the various jobs is moved either in small steel dump cars or in buckets carried on flat cars. The distance of transportation varies up to about ½ mi. At the C. & O. N. job concrete is moved from a central mixing plant to several structures within a distance of 3,500 ft. along the line. Dump-cars are used, tipping into a hopper at the point of delivery. At Harrisburg bottom-dumping buckets are used, seated on small flat-cars holding two buckets. These are run on a work-trestle built alongside the bridge and are lifted off by a locomotive crane.

Decorating a City Bridge with Structural-Steel Portals

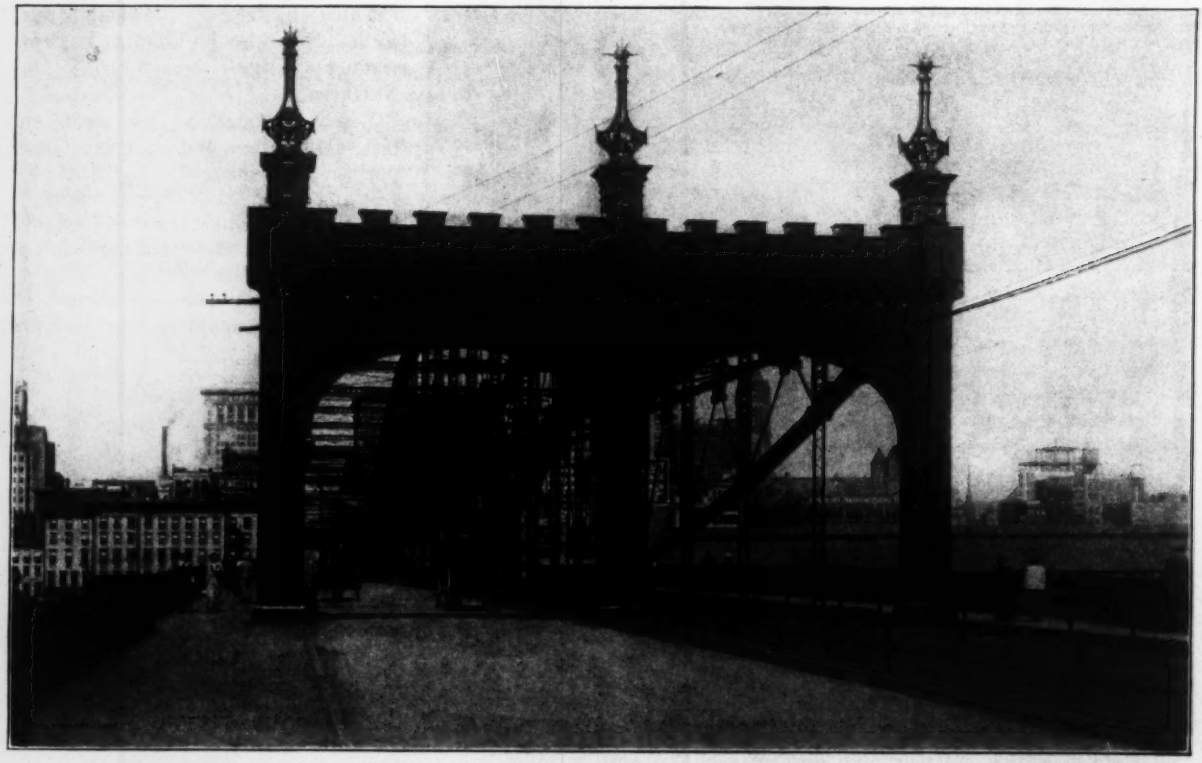
The most pretentious bridge portals in the United States are those recently applied to the Smithfield bridge across the Monongahela River in Pittsburgh. The old bridge, built in 1883, had cast-iron portals. It was at first a two-truss single-roadway bridge, but in 1890 the east (right-hand) truss was added, making a second roadway. As this roadway was narrower than the first one, and required specially narrow street cars, it was widened in 1911 by moving the east truss 4 ft. farther eastward. At this time the old cast-iron portals were removed. They had proved a nuisance, incidentally, because they made it impossible to paint the end-posts, and considerable rusting occurred at certain points in these posts. Some strengthening was needed here, and this has been accomplished by filling the end-posts with concrete, rammed under the top plate and bearing at the bottom on new upper-bearing castings, which were placed in sections inside the posts and over the pins. The new structural-steel portals built around the end-posts were also filled with concrete. These portals were designed by Stanley L. Roush, architect in the office of N. S. Sprague, Superintendent, Bureau of Engineering, Department of Public Works of the city. The Des Moines Bridge and Iron Co. fabricated the steelwork. The Thomas Lane Co. was contractor.

Placing Cast Concrete Slabs on Underwater Revetments

In repairing the Calumpang dike in the Province of Batangas, P. I., the design called for the placing of a reinforced-concrete slab protection on a rock fill to be deposited outside the existing hollow concrete wall dike. This rock fill extended only a foot or so above water level, so that most of the slab protection had to be laid under water. For this somewhat novel condition a special method of construction was devised in which slab sections were molded above water and after setting lowered to place. It is described in the "Quarterly Bulletin" of the Philippine Bureau of Public Works.



METHOD USED IN PHILIPPINE ISLANDS IN PLACING SUBAQUEOUS CONCRETE SLAB REVETMENT



NEW SOUTH PORTAL OF SMITHFIELD ST. BRIDGE OVER MONONGAHELA RIVER, PITTSBURGH

An ornamental structural-steel portal, replacing old cast-iron portals. The oldest part of the bridge dates from 1883

The rock fill was first dumped outside the old dike and shaped to its proper section. Its above-water surface was then covered with a mat of concrete slabs cast in place in 3x4½-ft. squares and provided with reinforcement which protruded with hooked ends a few inches below the lower edge of the slab. After these slabs had set, the rig shown in the sketch was set up. This rig consisted of a bridge supported at its shore end on blocks on the cast slabs and at its outer end slung by block and tackle from braced posts. From the upper chord of this bridge was hung a solid floor, on which was cast the reinforced-concrete slab with protruding hooks, by means of which the hardened slab was hung directly to the upper chord of the bridge.

After these slabs had reached a sufficient set, the lower floor was unslung and removed and the slab lowered into place, the slab pivoting at its upper end around the hook in the above-water slab 6 ft. for that purpose. Divers then cast off the supporting slings and the rig was moved to the next slab. Joints between the slabs were filled by concrete deposited through a tremie.

Table of Angular Deflections in Decimals of Feet

The accompanying table is self-explanatory. It has proved of great value in at least one engineering office, according to C. H. Eiffert, Assistant Engineer, Windes & Marsh, Engineers-Contractors, Winnetka, Ill., who computed it. The table gives deflections in decimals of feet for every minute of angle up to one degree. It is most commonly used in running random lines and is very useful for correction of bearings or obtaining offsets for given deflections. The table is designed to be in two parts, divided between 700 and 800, each half just fitting an ordinary field notebook.

ANGULAR DEFLECTIONS IN DECIMALS OF FEET

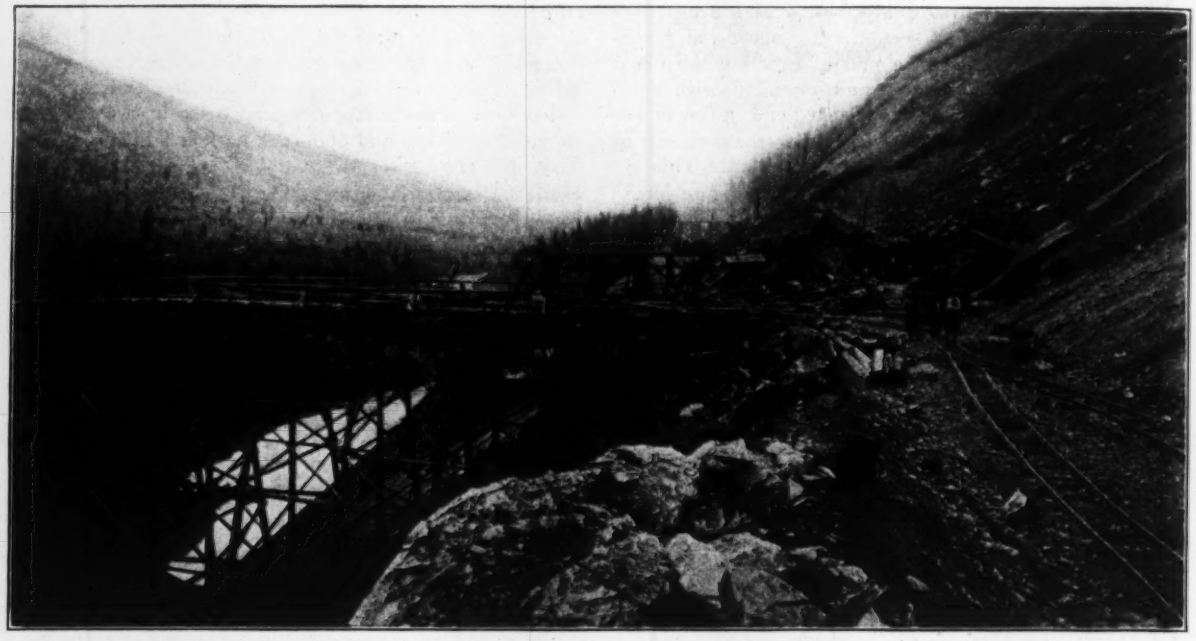
Min.	100	200	300	400	500	600	700	800	900	1000	660	1320	2640	5280	Min.
1	0.029	0.058	0.087	0.116	0.145	0.175	0.204	0.233	0.262	0.291	0.20	0.40	0.79	1.51	1
2	0.058	0.116	0.175	0.233	0.291	0.349	0.407	0.465	0.524	0.582	0.40	0.79	1.51	3.04	2
3	0.087	0.175	0.262	0.349	0.436	0.524	0.611	0.698	0.785	0.873	0.59	1.12	2.31	4.62	3
4	0.116	0.233	0.349	0.465	0.582	0.698	0.815	0.931	1.047	1.164	0.79	1.52	3.04	6.14	4
5	0.145	0.291	0.436	0.582	0.727	0.873	1.018	1.164	1.309	1.455	0.99	1.91	3.83	7.66	5
6	0.175	0.349	0.524	0.698	0.873	1.047	1.222	1.396	1.571	1.746	1.19	2.31	4.62	9.24	6
7	0.204	0.407	0.611	0.815	1.018	1.222	1.425	1.629	1.833	2.040	1.32	2.71	5.41	10.76	7
8	0.233	0.465	0.698	0.931	1.164	1.396	1.629	1.862	2.094	2.330	1.52	3.10	6.14	12.28	8
9	0.262	0.524	0.785	1.047	1.309	1.571	1.833	2.094	2.355	2.620	1.72	3.43	6.93	13.86	9
10	0.291	0.582	0.873	1.164	1.455	1.746	1.837	2.328	2.619	2.910	1.91	3.83	7.66	15.38	10
11	0.320	0.640	0.960	1.280	1.600	1.920	2.290	2.560	2.880	3.200	2.11	4.22	8.45	16.90	11
12	0.349	0.698	1.047	1.396	1.746	2.142	2.491	2.792	3.141	3.490	2.31	4.62	9.24	18.41	12
13	0.378	0.756	1.135	1.513	1.890	2.268	2.696	3.026	3.405	3.780	2.51	5.02	9.97	19.93	13
14	0.407	0.815	1.222	1.629	2.035	2.445	2.852	3.258	3.666	4.070	2.71	5.35	10.76	21.52	14
15	0.436	0.873	1.309	1.746	2.180	2.619	3.055	3.492	3.927	4.360	2.90	5.74	11.48	23.03	15
16	0.465	0.931	1.396	1.862	2.325	2.893	3.358	3.724	4.188	4.652	3.10	6.14	12.28	24.55	16
17	0.495	0.989	1.484	1.978	2.475	3.067	3.562	3.956	4.452	4.950	3.30	6.53	13.07	26.14	17
18	0.524	1.047	1.571	2.094	2.620	3.141	3.665	4.188	4.713	5.240	3.43	6.93	13.86	27.65	18
19	0.553	1.105	1.658	2.210	2.765	3.315	3.868	4.420	4.974	5.530	3.63	7.33	14.59	29.17	19
20	0.582	1.164	1.746	2.328	2.910	3.492	4.074	4.656	5.238	5.820	3.83	7.66	15.38	30.76	20
21	0.611	1.222	1.833	2.444	3.055	3.666	4.277	4.888	5.499	6.110	4.03	8.05	16.10	32.27	21
22	0.640	1.280	1.920	2.560	3.200	3.840	4.480	5.120	5.760	6.400	4.22	8.45	16.90	33.79	22
23	0.669	1.338	2.007	2.676	3.345	4.014	4.683	5.352	6.021	6.690	4.42	8.84	17.69	35.31	23
24	0.698	1.396	2.094	2.792	3.490	4.188	4.886	5.584	6.282	6.980	4.62	9.24	18.41	36.83	24
25	0.727	1.455	2.181	2.910	3.635	4.365	5.092	5.820	6.543	7.270	4.82	9.57	19.21	38.41	25
26	0.756	1.513	2.268	3.026	3.780	4.539	5.295	6.052	6.804	7.560	5.02	9.97	19.93	39.93	26
27	0.785	1.571	2.355	3.142	3.925	4.713	5.498	6.284	7.065	7.850	5.21	10.36	20.72	41.45	27
28	0.815	1.629	2.445	3.258	4.075	4.887	5.702	6.516	7.335	8.150	5.41	10.76	21.52	43.03	28
29	0.844	1.687	2.532	3.374	4.220	5.061	5.905	6.748	7.596	8.440	5.54	11.15	22.31	44.55	29
30	0.873	1.746	2.619	3.492	4.365	5.238	6.111	6.984	7.857	8.730	5.74	11.55	23.03	46.07	30
31	0.902	1.804	2.706	3.608	4.510	5.412	6.314	7.216	8.118	9.020	5.94	11.88	23.83	47.65	31
32	0.931	1.862	2.793	3.724	4.655	5.586	6.517	7.448	8.379	9.310	6.14	12.28	24.55	49.17	32
33	0.960	1.920	2.880	3.840	4.800	5.760	6.720	7.680	8.640	9.600	6.34	12.67	25.34	50.69	33
34	0.989	1.978	2.967	3.956	4.945	5.934	6.923	7.912	8.901	9.890	6.53	13.07	26.14	52.21	34
35	1.018	2.036	3.054	4.072	5.090	6.108	7.126	8.144	9.162	10.180	6.73	13.46	26.86	53.72	35
36	1.047	2.094	3.141	4.188	5.235	6.282	7.329	8.276	9.423	10.470	6.93	13.79	27.65	55.31	36
37	1.076	2.152	3.228	4.304	5.380	6.456	7.532	8.608	9.684	10.760	7.13	14.19	28.38	56.83	37
38	1.105	2.210	3.315	4.420	5.525	6.630	7.735	8.840	9.945	11.050	7.33	14.59	29.17	58.34	38
39	1.135	2.270	3.405	4.540	5.675	6.810	7.945	9.080	10.215	11.350	7.52	14.98	29.96	59.93	39
40	1.164	2.328	3.492	4.656	5.820	6.984	8.148	9.312	10.476	11.640	7.66	15.38	30.76	61.45	40
41	1.193	2.386	3.582	4.772	5.965	7.158	8.351	9.544	10.746	11.930	7.85	15.77	31.48	62.96	41
42	1.222	2.444	3.666	4.888	6.110	7.332	8.554	9.776	10.998	12.220	8.05	16.10	32.27	64.55	42
43	1.251	2.502	3.753	5.004	6.255	7.506	8.757	10.008	11.259	12.510	8.25	16.50	33.00	66.07	43
44	1.280	2.560	3.840	5.120	6.400	7.680	8.960	10.240	11.520	12.800	8.45	16.90	33.79	67.58	44
45	1.309	2.618	3.927	5.236	6.545	7.854	9.163	10.472	11.781	13.090	8.65	17.29	34.58	69.12	45
46	1.338	2.676	4.014	5.352	6.690	8.028	9.366	10.704	12.042	13.380	8.84	17.69	35.31	70.65	46
47	1.367	2.734	4.101	5.468	6.835	8.202	9.569	10.936	12.303	13.670	9.04	18.02	36.10	72.18	47
48	1.396	2.792	4.188	5.584	6.980	8.376	9.772	11.168	12.564	13.960	9.24	18.41	36.83	73.71	48
49	1.425	2.850	4.275	5.700	7.125	8.550	9.975	11.400	12.825	14.250	9.43	18.81	37.62	75.24	49
50	1.455	2.910	4.365	5.820	7.275	8.730	10.185	11.640	13.095	14.550	9.64	19.21	38.41	76.82	50
51	1.484	2.958	4.452	5.916	7.420	8.904	10.388	11.832	13.356	14.840	9.77	19.60	39.20	78.36	51
52	1.513	3.026	4.539	6.052	7.565	9.078	10.591	12.104	13.617	15.130	9.97	19.99	39.93	79.89	52
53	1.542	3.084	4.626	6.168	7.710	9.252	10.794	12.336	13.878	15.420	10.16	20.33	40.72	81.42	53
54	1.571	3.142	4.713	6.284	7.855	9.426	10.997	12.568	14.139	15.710	10.36	20.72	41.45	82.95	54
55	1.600	3.200	4.800	6.400	8.000	9.600	11.200	12.800	14.400	16.000	10.56	21.12	42.24	84.48	55
56	1.629	3.258	4.887	6.516	8.145	9.774	11.403	13.032	14.661	16.290	10.76	21.52	43.03	86.01	56
57	1.658	3.316	4.974	6.632	8.290	9.948	11.606	13.264	14.922	16.580	10.96	21.91	43.76	87.54	57
58	1.687	3.374	5.061	6.748	8.435	10.122	11.809	13.496	15.183	16.870	11.15	22.24	44.55	89.07	58
59	1.716	3.432	5.148	6.864	8.580	10.296	12.012	13.728	15.444	17.160	11.35	22.64	45.28	90.60	59
60	1.746	3.492	5.238	6.984	8.730	10.476	12.222	13.968	15.714	17.460	11.55	23.03	46.07	92.19	60

NOTES

Tin Speaking Tube Over Form Ties furnishes an easy means of removing the tie-rods used in concreting the piers of the Cumberland Valley R.R. bridge over the Susquehanna River at Harrisburg. The tube is cheap, and while it is not tight enough to keep out all mortar from the concrete, yet the rods are easily pulled out when the forms are stripped.

Concrete Cylinders as Form Spacers are being used on the reinforced-concrete walls of the new cotton terminal buildings under construction at Atlanta, Ga. These cylinders are cast in quantities. The molds for them are of such size as to make the cylinders 4 in. in diameter and 8 or 12 in. long. An opening is left through the axis of the cylinder to permit the entry of the wall-form tie-rods. After the wall has set, the rods are loosened and removed and the cylinders allowed to remain as a part of the wall.

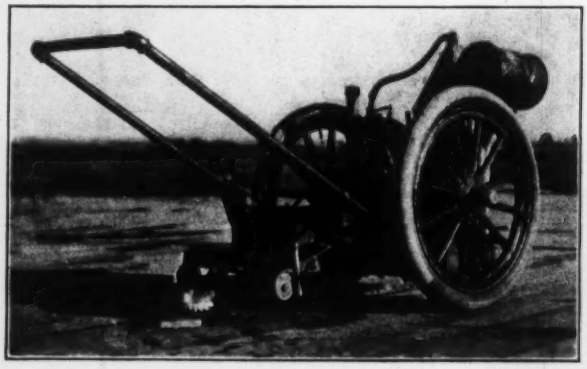
Dump Trestles for Sidehill Cuts—A novel method of disposing of material from sidehill cuts on the Pacific extension of the Canadian Northern Ry., recently opened to traffic, is illustrated herewith. For some distance through and beyond Yellow Head Pass the line is parallel with, but at higher elevation than, the Grand Trunk Pacific Ry. To deliver spoil clear of the latter line, timber trestles were built across it, carrying a dump-car track and having a dumping chute at the farther end. At the point shown, 32 mi. west of the summit, six of these chutes were required in a



DUMP TRESTLES ON THE CANADIAN NORTHERN RY.
These deliver the spoil from sidehill cuts clear of the Grand Trunk Pacific Ry. beneath

distance of 4,000 ft., the two lines being so close together. Three of these are shown, and they are on both sides of the tunnel, the west portal of which appears in the view. Over the six chutes about 307,270 cu.yd. of material was dumped, mostly rock. This work was under the direction of M. H. MacLeod, General Manager and Chief Engineer of the Canadian Northern Ry.

The Gasoline Saw used for jointing roof plank on a circular reservoir, as described in our issue of No. 25, is shown in the photograph herewith, sent by the Allinson & Cole Con-



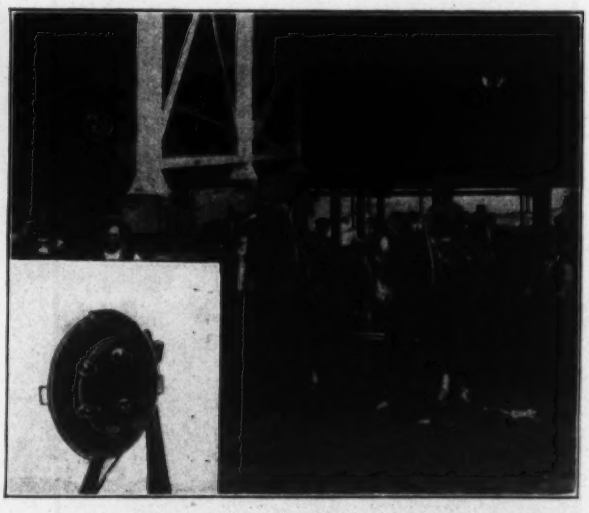
GASOLINE SAW USED FOR JOINTING ROOF PLANK OF CIRCULAR RESERVOIR

struction Co. The advantage of the rig over a motor-driven saw previously used was its being self-contained, free of wires or cables.

Portable Concreting Plants are used on two contract sections of a large water conduit for the Greater Winnipeg water-supply, now under construction in Canada. The concrete mixer is installed upon a car which runs on a track laid along one side of the trench. Each contractor is required by the specifications to provide a 300-ft. platform along the railway of the Water District, and upon this platform the District delivers the gravel and sand. A stiffleg derrick mounted on trucks on a broad-gage track, equipped with a 16-cu.ft. bottom-dump bucket, handles the materials to the mixer. The sand and gravel are shoveled from the platform into the buckets. Then either the derrick is moved to the mixer or the concreting car is run back to a point opposite the derrick. James H. Fuertes, consulting engineer for the District, states that considerable difficulty has been experienced with these plants owing to the breaking of the truck wheels. Ordinary cast-iron wheels have not given satisfactory service, and experiments with different grades of chilled cast-iron, semi-steel and other materials have not yet brought forward a wheel that will stand the work. The trucks probably will be replaced by others carrying more wheels.

Stair Treads of Concrete-Filled Channels are used in a new water-works plant at Crewe, Va. Each tread is a 10-in. 15-lb. channel with flanges turned up, carried by the stair strings by means of $1\frac{3}{8} \times 1\frac{3}{4} \times \frac{3}{16}$ seat angles. The strings also are 10-in. 15-lb. channels, flanges turned out. The treads are simply filled with concrete to the level of the top of the flanges, making a simple and satisfactory tread with protected edge. Anderson & Christie, of Charlotte, N. C., are the engineers of the station.

Homemade Reflectors for Electric Lights on construction work were recently noted on two jobs as far apart as Southern California and Long Island, New York. These reflectors are made of bright new dishpans, with four or more sockets for incandescent lamps roughly riveted to the bottom. As



HOMEMADE REFLECTORS FOR INCANDESCENT LIGHTS

long as they stay bright the dishpans are about as cheap and effective as any reflector that can be had; and as the life of a reflector on a construction contract is likely to be short, these dishpans probably stay bright as long as they are recognizable as reflectors.

Editorials

Broad Patent Principles and Reinforced Concrete

The decision of Judge Lewis in the United States District Court at Denver on the Luten concrete bridge patents, noted in full on another page, is important not so much because of its special application to the bridge or to the patents in question but because it lays down with commendable lucidity a principle long contended for by engineers but rarely, and then reluctantly, admitted by lawyers and the courts. This principle is that the arrangement of metal parts in a body of reinforced concrete to resist the stresses which are set up involves merely mechanical design and not *invention*.

It is an accepted principle of patent law that in order to be patentable an invention must embody something else than mere mechanical design. It is indeed difficult to draw the line between design and invention or to lay down any hard and fast rule by which to distinguish between them. This much can be said, however: That if a structure involves nothing more than skilled proportioning of parts to resist the stresses to which they are subjected the courts are not likely to sustain a patent upon it. Simply to describe and spread upon the patent records a combination of parts never used before does not give a man the right to a monopoly of that particular combination and power to collect damages from anyone else who may desire to use it. In order that a patent shall be valid it must cover an actual invention. What the Germans call "a new technical effect" must be produced.

It follows, then, in the opinion of Judge Lewis that as the essence of patentability is invention and not the adaptation of known design, patents involving the arrangement of reinforcement in concrete are not valid, mainly because fifty-odd years ago Francois Coignet described the reinforcement in concrete as "a metallic framework linked or arranged so as to strengthen the same."

In the few reinforced-concrete patent suits that have hitherto come to a regular trial, the judges as a rule have not been able to follow the general principle to its specific instance. They have, indeed, been overwhelmed with the apparent novelty of reinforced concrete and have been ready to accept its manifold variations as absolutely novel structural effects demanding the extraordinary skill of the inventor rather than the art of the designer. These decisions engineers have constantly resented and the demands for royalties have been consistently regarded as impositions, not because of a wish to deprive the so-called inventor of the profit of his thought, but because of a feeling that the inventor was capitalizing for his own benefit the accrued knowledge of the profession.

In its narrow application the Lewis decision, if upheld in the higher courts, will measurably clear the reinforced-concrete patent situation. It will sweep aside the numerous annoying patents in which a clever engineer has had recorded in the files of the Patent Office various distributions of reinforcing rods in so many arrangements that it is practically impossible to reinforce a structure without imitating one of them. It will perhaps call to the attention of less analytical judges that because an engineer shows in his patent drawings a retaining wall with the reinforcing rods clearly outlined in its section he has not improved on the idea of a predecessor who many years before showed that same wall without the rods therein specifically indicated.

In its broader sense, however, the decision should have a far-reaching effect on all structural patents, for it should serve to emphasize the fact that any structure which a competent engineer would naturally arrive at through the orderly development of the principles of design cannot be held as an invention. It would prevent, for instance, the patenting of a fish-bellied, separately cast reinforced-concrete T-beam for a bridge girder, because an engineer of ordinary accomplishments would soon come to the conclusion in the course of his design of a separately cast concrete girder that material could be saved by reducing the depths at the ends. Yet such a girder has been patented, and royalties are being demanded for its infringement.

Especially noteworthy, also, in Judge Lewis' decision is his reference to the prior decisions in favor of the Luten patents in suit. It has become the custom in patent cases—a custom for which there is much to be said—to allow decisions in favor of a patent in one judicial circuit practically to control the decision in other circuits. In the present case it was urged on behalf of the patents in suit that decisions in favor of Luten had been rendered in fourteen other suits involving the validity of these patents. Concerning these decisions, however, Judge Lewis says:

> In all of those cases the decrees and judgments offered in evidence show that they were had either pro confesso or by agreement, and if not by agreement, it is admitted that no defense was in fact made. . . . Experience has given me the impression that it has become a favored method to follow that practice for the principal purpose of thus building a basis on which to attempt to sustain a patent when it is later seriously contested.

At the present time royalties are being demanded on account of some other patents on reinforced-concrete construction on the basis of prior decisions sustaining the validity of the patents. In view of the foregoing statement by Judge Lewis, it is probable that there will be a very careful overhauling of the records in these cases, and it may well be that the courts will be more inclined to investigate these prior decisions than has been the case hitherto.

Engineering-Society Cleavage

Why cannot there be a single engineering society for all America? One answer is that there is altogether too much cleavage in the profession, both vertical and horizontal. The vertical cleavage follows both professional and geographical lines. Although lateral pressure tends to close up the breaks here and there, constant and seemingly irresistible forces continually open up new gaps,

resulting in brand-new societies or at the least the formation of sections and subsections in old ones. As to horizontal cleavage, this is in evidence at the organization of every society that has classes or grades of membership. In the course of time the class or grade consciousness increases to such an extent that new societies are formed from both the higher and the lower strata. Notable examples of horizontal cleavage and the beginning of separate existence are the American Institute of Consulting Engineers, formed a few years ago to further the interests of super-engineers, and several recently organized societies for the uplift of subclass engineers.

The onlooker can find much to interest him in studying these engineering-society cleavages. He sees no end to the breaks and separations, but in them all, regardless of occupational or geographical divisions and class or caste distinctions, there can always be seen the weaknesses and foibles as well as the nobler elements of human nature.

Let us take the super-engineers, as best fitted by their elevated position to be exposed to view. Hours of discussion have been devoted by them to the pros and cons of disciplining some member against whom complaint of unprofessional conduct has been lodged. In these discussions there has been a tendency to a sharp division—horizontal or vertical, as one may choose to call it—into two portions, one party ready to excuse or palliate an alleged ethical offense, the other uncompromisingly refusing to do so.

Or, again, take the super-engineer's recent division—be it horizontal or vertical—over the ethics of serving as consulting engineer for a company or project in which the consultant has a proprietary interest. This subject has agitated the super-engineers for more than a year. True, the question was brought up by would-be members—mining engineers—who in seeking admission to the super-engineer's society found that its code of ethics forbade the practice just mentioned. The question having been referred to the proper committee, a report was submitted in September, 1914, to the effect that the rules of the society ought not to be modified "to suit the convenience of any particular branch of the profession," since "to do so would mean the loss of what has been gained by us during the years" the rules have been in effect. What the membership at large or those at the meeting thought of this conclusion each reader may infer for himself from the statement that the "report was ordered filed."

The question would not stay down. In April, 1915, a letter reached the secretary stating "why mining engineers could not subscribe" to the rules. This letter was sent to all the super-engineers. The result was evidence of cleavage—horizontal or vertical—but by only nine members. These nine "favored amendment" of the rules. The majority of the committee held fast to the rules. A minority was "unable to agree" that the rules ought to remain unchanged, but thought it "inexpedient to submit a minority report at this time."

All of which shows that the super-engineers are still human beings, subject to much the same laws of cleavage as cause the sub-engineers to subdivide into various classes or strata. Until these cleavage forces cease acting there will be not one but an ever-increasing number of engineering societies—a condition not without its compensations, although a change in some of the cleavage lines would be wholesome.

Trains on Steep Grades

The terrible railway accident on the Mexican railway in which some 300 people were killed and injured, as noted last week, seems to have been due largely to careless operation of the line under semi-military control. A careful engineman finding his train detached on a 4% grade would surely have realized that the brakes would hold the cars and would have ascertained the position of the train before backing up at such speed as to strike the train and drive it downhill.

While this railway has been notably free from accidents, consideration may well be given to the protection of traffic on its long, steep and winding stretch of line. No such action can be expected, however, until Mexico is in a more settled condition and railway operation again on a normal basis. Catch sidings at intervals and guard rails on the curves might be provided, but an accident might easily occur between the sidings, or the speed prove too great for the guard rails to be effective. Emergency chain couplings to the engine, normally slack, might also be used. Probably the most effective mechanical preventive of runaways would be brakes so adjusted that they will hold, and at least prevent a detached car or train from attaining dangerous speed. In the case of descending trains, practically all reliance must be placed on the brakes.

The Laborer's Wage and the City Engineer's Salary

If the service of day laborers is worth $2.50 a day to a city, how much should the city engineer be paid? The question has just arisen at Aberdeen, Wash. That enterprising city is about to spend $400,000 for a new water-supply. On a night when the City Council was taking action to further the project an ordinance was passed establishing $2.50 as a minimum wage for city laborers and for laborers on municipal contract work. Another ordinance was passed raising the salary of the city engineer, on account of the extra work in sight, from $175 to $250 a month. The worthy mayor promptly announced that he would veto the salary-increase ordinance. Among the dire results predicted if the salary increase stands are that taxpayers would "be more critical of the engineer and condemn him more in case of small mistakes"; "dissatisfaction among his helpers"; some "will begin to believe that the $400,000 voted by the people is a sort of 'pork barrel' from which everyone has a right to grab and get a big handful"; right-of-way owners "will want more for their property than it is actually worth"; "to increase the engineer's salary at this time would be harmful to the economic building of the system."

The mayor graciously or justly remarks that no one in Aberdeen "is giving more time to the city and thinking more about its projects" than the city engineer; but he adds that the "water project is demanding sacrifices from everybody," including taxpayers, city engineer, city attorney, councilmen and practically every city official. Finally, the mayor believes that the opportunity the project affords the city engineer "to display his real mettle" will partly compensate him "for a smaller salary than might be allowed him somewhere else."

The mayor is not recorded as saying a word against $2.50 a day as a minimum for laborers. That price may

or may not be excessive in Aberdeen. But is not the engineer as well as the laborer worthy of his hire, minimum wage and all?

Justice to the Aberdeen council makes it necessary to say that the vote in favor of the minimum wage for the laborers appears to have been 7 to 5, while that for giving the city engineer $3,000 instead of $2,100 a year was 10 to 2. If the mayor vetoes the salary increase there would therefore seem to be an excellent chance that the council will muster the necessary two-thirds vote to override the veto. If so, it seems perfectly safe to say that instead of the dire results predicted by the mayor the small sum involved will prove to be money well invested.

Since the foregoing paragraphs were written, news has come across the continent that shows the council lacked the backbone credited to it, since it repealed the salary-increase ordinance before the mayor vetoed it. No word has come that the laborer's minimum-wage ordinance has been repealed.

A Way To Pay for Good Roads

Missouri is one of the few states which has not yet embarked on an extensive state-road building program, and so the people of that state are still listening to the old familiar good-roads arguments. That farmers' hauling costs may be reduced from 30 or 40c. to 5c. per ton-mile by good roads is an argument as old as the good-roads movement, but Fred D. Gardner in a recent address before the Implement, Vehicle and Hardware Association of St. Louis put forth another argument, the proof of which may be more easily demonstrated. He would assess every owner of a motor vehicle $10 per year for five years, thus providing an estimated fund of $5,000,000 for road improvement. He claims—and he is a transcontinental motor tourist—that each motor-vehicle owner would save at least $50 a year in tires by the introduction of smooth, hard roads.

The wear and tear on automobile bodies and tires because of rough roads ought to be much more demonstrable to good-roads propagandists than the reduction of farm hauling costs. The farmer argument has been overworked. Why not face the issue thus squarely and ask those who want good roads most to share the cost directly, at least in proportion to their actual saving by the improvements? Of course the howl from the automobile owners, both individually and in associations, will be louder than their present "good-roads" clamor, but perhaps they could be made to see the light.

Acres of Tracing Cloth and Hogsheads of Ink

A large-sized filing cabinet will be needed by the Valuation Division of the Interstate Commerce Commission at Washington, D. C. The law requires every steam-railway carrier to file with the commission maps and profiles of its entire system. The maps are of standard size, 23x55 in. inside the border lines, on scales of 100, 200 or 400 ft. = 1 in. The profiles are 10x55 in. inside the borders and on a scale of 20 ft. = 1 in. vertical and 400 ft. = 1 in. horizontal.

It is estimated, according to F. C. Sheperd in a paper presented before the Boston Society of Civil Engineers, that the Boston & Maine R.R. will have to file about 3,000 maps and 750 profiles. The Boston & Maine R.R. comprises 2,300 mi. of track. There is about 370,000 mi. of track in the United States, and computing the number of maps required by the same ratio as on the Boston & Maine, we have 484,000 maps and 121,000 profiles.

These Government file maps must be on tracing cloth, which will require about 537,000 sq.yd. (4,840,000 sq. ft.) of plain tracing cloth and 67,000 sq.yd. (600,000 sq.ft.) of profile tracing cloth (Plate A). As the railways will very likely not want to file the originals with the Government, tracing-cloth copies of the originals will have to be made, doubling the consumption of tracing cloth to 1,000,000 sq.yd. and 130,000 sq.yd. respectively—a total of 1,130,000 sq.yd.

Engineering News is informed from reliable sources that ordinary tracings require about one quart of black drawing ink to every 100 sq.yd. of tracing cloth, so for these railway-valuation maps about 11,300 quarts of drawing ink will apparently be the quantity required.

Letters to the Editor

How To Light Blasting Fuses

Sir—I have noticed some discussion by T. R. Martin and others in the last numbers of *Engineering News* on the best way to light the ordinary safety blasting fuse. I have had my share of nervous thrills in trying to light a stubborn fuse with others burning beside me and have found that the best way to "spit" a number of fuses is to use a short piece of the blasting fuse itself.

Notch the short piece along one side, every inch or so in length, open the notches so that the powder is exposed and light the short piece. At every notch the powder will spit such a strong flame that it will be a very stubborn fuse indeed that will not be lighted instantly by it.

Wenatchee, Wash., Oct. 26, 1915. F. J. SHARKEY.

Sewer Gaging at Seattle in the Light of St. Louis Gagings

Sir—In connection with the article on sewer gaging in Seattle published in your issue of Oct. 28, I wish from our experience in St. Louis to offer a few comments and suggestions.

The sewer-gaging work in St. Louis was started in 1910 and has been kept up carefully and on an extended scale since that time. We now have in the sewers about 20 gages of the Bristol and Foxboro types. We are also using about six tipping-bucket rain gages, besides a number of standard gages.

Our first installation of the Bristol gages was similar to that described by Mr. Silliman, and we experienced

all of the troubles that he has described, and some others. We found that our "moisture-proof" cases were not moisture-proof when installed in the sewer manholes, and at the end of the first year these cases were set on posts back of the curb line, the air tube being carried under the pavement into the sewer.

We found that the accumulation of rubbish on the bulbs when supported in the center of the sewer was so great as practically to destroy the value of the records and in our present work the bulbs are installed in wooden boxes bolted to the side of the sewer and set high above the ordinary flow of sewage. In fact, we have found that the results from light rains are of so little value that in most cases the bulbs are installed just below the spring lines of the sewer. These boxes are in the shape of flat triangles, with the long side against the sewer wall, and have a coarse wire mesh on top and bottom.

We also had a great deal of trouble with the regulation of the clocks on these gages, particularly in the earlier years, and even now it is sometimes necessary to prorate an error of several minutes throughout the 48-hr. run. Owing to the large number of gages in use and to the fact that we could only keep two trained observers on this work, we have found it advisable and entirely satisfactory to allow the instruments to run around twice, and have never had a case where we were not able to identify the lines to their proper days.

In studying the Seattle charts I have noticed two eccentricities which might be explained by some of the experiences that we have had. Their chart from May 27 shows the peak of the flow at about 2:33 p.m., while there is no reason whatever for its occurrence before 2:43 p.m. Here I would suggest that there was probably some trouble with clock regulations.

Their chart for Nov. 10 and 11 shows an almost instantaneous rise at 12:30 midnight, which the rainfall could not possibly account for. From similar experiences I would like to ask Mr. Silliman whether it is not possible that the first rush of the water, bringing down a large amount of débris, may not temporarily have created a dam against his sewer bulb.

I do not think Mr. Silliman's definition of the percentage of runoff is clear; or at least according to my reading of it, the factor described is not one usually used.

I think Mr. Silliman is in error in describing the district gaged as a 20-min. district. The district is of a very peculiar shape, and I believe that if sewers were being designed for it, it would be found that the maximum discharge would result from the heaviest 15-min. rain falling on the body of the district and ignoring the two long tongues.

By inspection of these figures for running time the total drainage area seems to be divided about as follows:

	Per Cent.
Within 5-min. time	12
From 5- to 10-min. time	45
From 10- to 15-min. time	35
From 15- to 18-min. time	8

The times are for flow through the sewer only.

As all of his grades are apparently very steep, the time of flow to the inlet should not be over 5 min. It should therefore be apparent that for the first 5 min. after the beginning of the rain there should be practically no runoff; for the second 5 min., only from about 12% of the area; that for an intense precipitation lasting only 5 min. the maximum flow should occur about 15 min. after the beginning of the rain; for an intense precipitation approximately uniform for 10 min. the maximum flow should occur 20 min. after the beginning of the rain and that the same would be true for a uniform precipitation for a 15-min. duration.

Referring again to the records given, the storm of Nov. 10 and 11 was uniform for 15 min.; but from the chart it appears that the peak did not occur until 30 min. after the beginning of the rain. This is not only not in accord with the conclusions drawn by Mr. Silliman, but it is so unusual that it seems advisable to ask how the 0.08 in. of rainfall between 12:35 and 1 a.m. was distributed. The record for Oct. 30 gives one 5-min. period of very intense precipitation and the peak occurs apparently about 8 min. from the beginning of this period. Here again I should look for clock trouble, as we know that it is impossible that the water from a large proportion of the drainage area could reach the gage in that time.

The rain of June 6 is continuous for 20 min., and as would be expected, the peak occurs 25 min. after the beginning of the rain. This is again divergent from the conclusions which Mr. Silliman draws. The gage on May 27 shows the peak occurring at the end of the first 5 min. of precipitation, when it is obvious that no more than 15 or 20% of the drainage area could be tributary.

I should not have thought of questioning the accuracy of the observations in Seattle were it not that the wide divergence in results is so nearly paralleled in my own experience, and further that in my work more detailed and continued study had not offered explanation of the inconsistencies.

As an example, we had three gages on one tangent of a 9-ft. sewer. The upper two were about 800 ft. apart, with practically the same drainage area. The lowest gage was 400 ft. below the middle one and a 3x4-ft. sewer entered about 100 ft. above it. The middle gage consistently through all records showed stages that indicated flows of from 70 to 95% of those at the upper one, while the lower often indicated discharges so large as to be out of all proportion to the increase in area. The installation of additional gages indicates that there must be an acceleration on this tangent, and hence a lowering of stage until the tributary mentioned is reached, when the stream is so badly broken up that something similar to the hydraulic jump occurs.

Additional study is being made to determine characteristic velocities at one of the upper gages, from which it is expected all the records can be corrected within reasonable limits.

This study is also bringing out the fact that the flow in sewers does not occur with the precision and propriety that our formulas are wont to assume. It also has indicated clearly the necessity of careful attention to the small details of curves and intersections.

In conclusion, I am of the opinion that Mr. Silliman has made a mistake in attempting to make any deductions from four records of a single gage, and I cannot find that the records published would warrant either the conclusion which he has apparently reached or any others in so far as the time of occurrence of the maximum flow is concerned.

W. W. Horner,
Engineer in Charge Sewer Design.

St. Louis, Mo., Nov. 3, 1915.

[Mr. Silliman's reply to Mr. Horner's letter follows.—Editor.]

Sir—I have read Mr. Horner's letter with interest and profit. My impressions from his letter are that Mr. Horner concedes that there is some truth in my deductions, when, in order to justify his deductions, he shortens the running time of the district to 15 min.

The running time, as shown on the plat of the district, was calculated by using Kutter's constants, $n = 0.013$ for pipe sewers and $n = 0.015$ for brick sewers.

Many of the sewers in this district are more than 20 yr. old. The intercepting sewer was constructed in 1894. In all the velocity measurements that I have made I have not found an old sewer that had more than 90% of its calculated velocity, using the foregoing constants. Some ran as low as 75% of the calculated velocity.

Nothing could be farther from the truth than Mr. Horner's assumption that my deductions were made from "four records of a single gage." If I could get the money I would purchase several more gages, but could not hope to rival the St. Louis layout of "twenty gages and six tipping-bucket rain gages."

My deductions were based not only on the records from the First Avenue Intercepting Sewer District for the year 1914, but included the results shown by the records of the sewage flow in two large drainage districts. One of these districts had at the time the gagings were taken an area of approximately 2,000 acres above the point where the gage was installed. The time of running from the recording gage to the farthest-removed storm-water inlet on the main sewer that did not have storm-water overflows was calculated to be 48 min. From the recorded flow of seven storms, occurring on Mar. 22 and 28, Apr. 2, 4, 14, 26 and 27, 1914, the average time interval from the end of the 10-min. period having the maximum rate of precipitation to the time of maximum flow in the sewer at the recording gage is 27 min., which is 3 min. more than one-half the running time.

The other drainage area from which we have records of the sewage flow has a sewered area of approximately 7,000 acres above where the recording gage was installed. The distance from the recording gage to the farthest-removed storm-water inlet is 9.25 mi. The calculated time of running from the recording gage to this inlet is 2 hr. 40 min. The records show that in four storms, occurring on Oct. 16, Oct. 30, Nov. 12 and Dec. 30, 1914, the maximum flow was recorded at the average time for the four storms of 1 hr. 37 min., after the hour having the greatest rate of precipitation. The rate of precipitation was practically uniform throughout the hour for these storms, except in the fourth, when 72% of the fall occurred in 10 min. The maximum flow occurred 1 hr. 43 min. after this 10-min. period.

These records seem to me to justify my deductions regarding the time of maximum flow in a sewer after the period having the greatest rate of precipitation.

In the September, 1913, *Journal* of the Western Society of Engineers is a paper entitled "Rainfall and Its Runoff into Sewers," by Samuel A. Greely. In the discussion of this paper by Mr. Horner on page 703, Fig. 9—"Graph of a St. Louis Sewer-Flow Determination"—he gives the time of concentration of the district from which he took his record as 26 min. The rainstorm begins at 8 a.m.; the maximum rate of precipitation occurs from 8:05 a.m. to 8:10 a.m.; the maximum flow in the sewer occurs at 8:15 a.m., a time interval from the beginning of the storm which is approximately one-half the time of concentration given.

Another point raised by Mr. Horner is clock trouble. The man who takes the records from the recording gage in the First Avenue Sewer has always reported that there was no error in the timing of the gage clockwork. In the other recording gage, at the end of one year of service the clock was losing about 3 min. in 48 hr. At that time it was regulated, and no appreciable error can be detected at the present time.

For the record in which Mr. Horner insists damming occurred, the record shows that within 1 hr. after the rainfall stopped, the depth of flow in the sewer was the same as that when the storm began. What became of the dam?

A study of the meteorological conditions on the day of each storm and for a period of several days before each storm affords a rational explanation of the variations in storm-water runoff shown.

HENRY D. SILLIMAN,
Assistant District Engineer.

Seattle, Wash., Nov. 18, 1915.

Treated Ties on the Southern Pacific Ry.

Sir—In an editorial entitled "Treated Ties Are Little Used," in your issue of Oct. 14, it is indicated that the Baltimore & Ohio R.R. had treated ties in its tracks to the approximate total of about 7% of the whole, and that probably few roads could make so good a showing of treated ties compared to the total number used in renewals.

The Pacific System of the Southern Pacific Co., containing about 7,000 mi. of road, has for approximately 18 yr. made an extensive use of treated ties in renewals. During the fiscal year ended June 30, 1915, tie renewals were divided as follows: Treated ties, 1,730,259 = 75%; untreated ties, 575,658 = 25%; total ties renewed, 2,305,917.

The percentage of all kinds of ties in all tracks at the close of the fiscal year was as follows: Treated fir, 61.80%; untreated fir, 16.76%; untreated redwood, 20.88%; untreated cedar, 0.56%. The untreated fir ties are largely accounted for by reason of their application to heavy curvature or for heavy yard and switching service, where mechanical wear determines the life before the untreated tie decays. Redwood ties, on account of their decay-resisting qualities, do not require treatment.

It will be seen therefore that this company has long maintained a policy of treating practically all ties used in renewals that required it, or where any advantage would accrue to the company by so doing.

J. Q. BARLOW,
Assistant Chief Engineer, Southern Pacific Co.

San Francisco, Calif., Nov. 8, 1915.

[The figures of the untreated ties used in renewals on the Baltimore & Ohio R.R. in the year ended June 30, 1915, are not at hand, but the number of treated ties used was about 50% of the total estimated as desirable for treatment. On the Southern Pacific Ry. they were 75% of the total renewals.—Editor.]

Six Concrete-Bridge Patents Void on Broad Grounds

The Luten suit against Weld County, Colorado, for infringement of concrete bridge patents was decided against the patents by District Judge Robert E. Lewis of the Colorado Federal district court, at Denver, Nov. 13, 1915, in a decision remarkable for its scope. If upheld, it is likely to affect most reinforced-concrete patents. It declares the alleged inventions nonpatentable at the time of application. The earliest patents on reinforced concrete cover a combination of concrete and a metal skeleton so placed as to strengthen it; and by mechanics the points of greatest stress in a structure can be determined.

Besides giving this broad ground for declaring the patents invalid, Judge Lewis says that several of the patents represent mere exercise of mechanical skill and others are completely anticipated by prior patents.

The complete text of the opinion which follows is accompanied by sketches, copied by *Engineering News* from the patent drawings, showing the particular point involved in each patent under litigation.

It is of interest to note that the particular claims under litigation are only a small part of the total claims under each patent. Indeed, in the six patents which finally were considered the total claims in each were 51, 35, 23, 22, 3 and 4 respectively.

Daniel B. Luten, Complainant, vs. George Washburn et al., Defendants.

Weld County through its codefendant, Washburn, constructed a reinforced-concrete bridge having one span of about 30 ft. across what is known as Sheep Draw on one of the public highways within that county; and thereafter the complainant brought his bill, in which he alleges that the defendants in so doing had been guilty of infringement of each of seven patents theretofore issued to him. The patents on which the suit is based are set up in the bill by the complainant thus, viz.:

1. Letters Patent No. 852,970, issued on May 7, 1907, for certain new and useful improvements in bridges or arches of concrete or other analogous material, application for which was filed by complainant, as he alleges, on Feb. 13, 1905.

2. Letters Patent No. 853,183, issued May 7, 1907, for new and useful improvements in concrete or similar arches, application for which was filed by complainant, as he alleges, on June 24, 1905.

3. Letters Patent No. 853,202, issued May 7, 1907, for certain new and useful improvements in arch structures, application for which was filed by complainant, as he alleges, on July 25, 1904.

4. Letters Patent No. 853,203, issued May 7, 1907, for certain new and useful improvements in arches, application for which was filed by complainant, as he alleges, on July 25, 1904.

5. Letters Patent No. 933,771, issued Sept. 14, 1909, for certain new and useful improvements in concrete bridges, application for which was filed by complainant, as he alleges, on Mar. 29, 1909.

6. Letters Patent No. 979,776, issued Dec. 27, 1910, for certain new and useful improvements in reinforced structures, application for which was filed by complainant, as he alleges, on July 23, 1904.

7. Letters Patent No. 989,272, issued Apr. 11, 1911, for certain new and useful improvements in reinforced structures, application for which was filed by complainant, as he alleges, on Dec. 9, 1908.

The answer pleads the general issue as to each patent; it also denies invention as to each patent; denies that complainant was the original and first inventor as to each; and sets up anticipation in other named patents and also description in named printed publications more than two years prior to complainant's several applications, and that each includes and covers matters of public and common knowledge and in public use for more than two years prior to the applications and more than two years prior to the supposed discovery by complainant. The answer also specifically denies infringement.

The relief sought is injunction against further alleged threatened infringement and for profits and damages.

The bill also sets up adjudications in favor of complainant in fourteen separate suits or actions which he brought in other jurisdictions, in which the validity of one or more of these patents was involved in each of said suits or actions. But in all of those cases the decrees and judgments offered in evidence show that they were had either pro confesso or by agreement, and if not by agreement, it is admitted that no defense was in fact made. Experience has caused me to feel that such proceedings ought to be given but scarce, if any, weight. I will go so far as to say that experience has given me the impression that it has become a favored method to follow that practice for the principal purpose of thus building a basis on which to attempt to sustain a patent when it is later seriously contested, and I have of late declined to

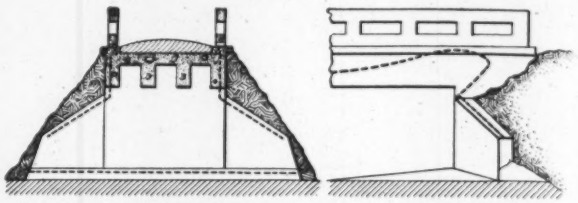


FIG. 1. ILLUSTRATING CLAIM FROM PATENT 852,970

enter such decrees if, after inquiry as to the true facts, I could appropriately avoid doing so.

At the trial the complainant did not introduce patent No. 933,771, but relied on the other six.

A. The claims under patent No. 852,970, on which reliance is placed to establish that defendants' bridge was an infringement, relate only to the wings and abutments of the bridge, and consist in the binding together of each wing to each abutment, and the abutments and the two wings at either

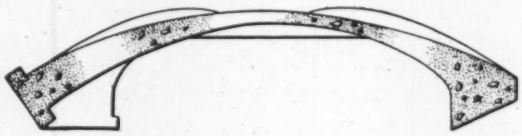


FIG. 2. ILLUSTRATING CLAIM FROM PATENT 853,183

end of the bridge by reinforcing rods extending into and through them.

B. The claims under patent No. 853,183, on which reliance is placed to establish that defendants' bridge was an infringement, relate to the formation at the juncture of the outer rib or girder of the bridge at each of its ends with the abutments—i.e., an arched kneebrace set in the under angle formed by the girder and abutment as distinguished from the triangular kneebraces under the inner girders; and also in the structure having two outer ribs or girders projecting both

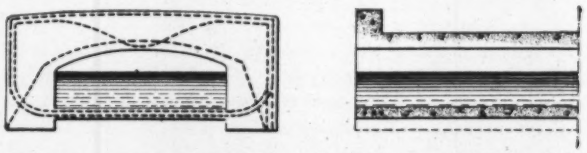


FIG. 3. ILLUSTRATING CLAIM FROM PATENT 853,202

above and below and with a roadway between the upper ribs or girders, with reinforcing members in the lower ribs.

C. The claims under patent No. 853,202, on which reliance is placed to establish that defendants' bridge was an infringement, relate to a bridge spandrel or retaining wall of concrete with reinforcing members near the stream and roadway surfaces, to the extension of such spandrel or girder across the abutment and cantilevered on the abutment with tension members extending across the abutment near the upper surfaces of the spandrel or girder, to longitudinal reinforcing tension members near the lower surface of said spandrel or girder, said tension members having upward extensions toward the ends of the girders, and to reinforcing tension members embedded near the lower surfaces of said spandrels or girders and having a plurality of shear members extending upwardly and inclined toward the ends of the girders, and tension members embedded near the upper surfaces of the girders and over the abutment.

D. The claims under patent No. 853,203, on which reliance is placed to establish that defendants' bridge was an infringement, relate to the reinforcing members in said bridge transverse to the roadway and extending upward into the wall or

spandrel near its back face, reinforcing members embedded transverse to the roadway and extending upward into the wall or spandrel and having such transverse members overlapping other reinforcing members embedded into wall or railing.

E. The claims under patent No. 979,776, on which reliance is placed to establish that defendants' bridge was an infringement, relate to reinforcing members in the girders in said

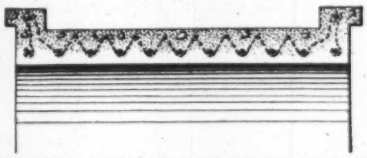


FIG. 4. ILLUSTRATING CLAIM FROM PATENT 853,203

concrete bridge comprising a lower horizontal tension rod and upper and lower shearing rods, each having a central horizontal part, inclined parts extending outwardly from opposite ends of the central parts, and the horizontal parts extending outwardly from the ends of said inclined parts, the central horizontal part of the lower shearing rod being longer than that of the upper shearing rod, and the horizontal ends of the upper shearing rod being longer than those of the lower shearing rod.

F. The claims under patent No. 989,272, on which reliance is placed to establish that defendants' bridge was an infringe-

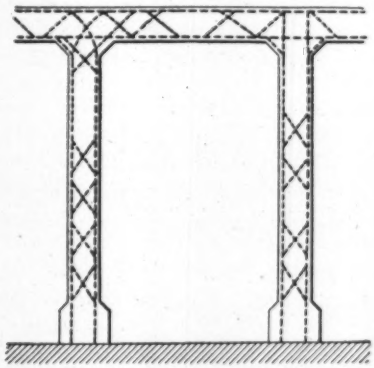


FIG. 5. ILLUSTRATING CLAIM FROM PATENT 979,776

ment, relate to the use of embedded tension members reinforcing the concrete abutment and the outer concrete rib or girder continuously adjacent the surfaces opposite the kneebrace, and extending away from said opposite surface of the transverse member intermediate its middle and the kneebrace and other tension members embedded longitudinally through the kneebrace.

On consideration of prior patents and publications introduced by the defendants to meet the separate and several claims, I am unable to rid myself of the firm belief and conclusion that each and all of complainant's claims were nonpatentable at the time he made his several applications, and also at the two times prior to applications when he claims he first, within two years prior to such applications, made practical use of the claimed inventions in those two instances. The prior patents as anticipations and the prior patents and publications as showing the then state of the art lead to the clear conviction that complainant in each instance only then made application of mere mechanical knowledge and skill, and that what he did is in no sense a demonstration of inventive genius. This is also the opinion of the defendants' expert witness.

The complainant as a witness disclaimed that his patents, or any of them, embodied anything beyond or more than placing "the steel in a new way that produces better results in a more efficient form. Now, in a concrete bridge the greatest efficiency is always secured by resisting tension or pull with steel rods. That has been established for half a century; not perhaps with curved tension members, but the basic idea is very old. There is no question about that." But none of complainant's patents in its specification, including drawings and in the claims, gives any specific direction as to just where any of the reinforcing members should be placed. This I suppose would in each instance depend upon the maximum load to be carried, the length of the spans and other elements which involve mechanics only, and would necessarily, I assume, be worked out in determining the amount of compression and tension under the established formulas in statics. In a general way the points of greatest stress can be roughly approximated without the use of mathematical tables, but this is centuries old—that is, it is open to common observation, and the fundamental purpose of reinforcing concrete was to strengthen the structure at these points; such a discovery in Luten's day is no evidence of inventive genius.

A bridge girder, for instance, is commonly known to be in compression on its upper side and in tension on its lower side; hence the greatest necessity for them through the latter region, and if carried continuously through and anchored in the outer face or foot of the abutment, it is but adding the element of suspension in bridge construction, which is old. This but illustrates. The same applies to the other points relied upon in Luten's patents.

The earliest patent relied upon in anticipation against all of the claims is that issued to Francois Coignet in 1869 (No. 88,547), described in the specification as being improvements in artificial stone, monolithic structures and artificial stone articles, in which the second claim reads: "The introduction, in the body of artificial stones, or in the body of artificial stone monolithic structures, made of agglomerated artificial stone paste, of skeletons, or metallic framework, linked or arranged so as to strengthen the same." That issued to Hinckley (No. 623,904), Apr. 25, 1899, expressly shows the application of tensile strength by carrying the rod continuously well into the abutments, and also the reinforcement of the spandrel or upper girder against outward thrust from the roadway by rods carried upward into it.

The publications cited against each of the patents are voluminous, and both foreign and domestic, and include drawings and plans with description of the same, in which the reinforcing members have been placed both in bridge and other structures so as to meet the strain where it falls in each instance. These publications so cited are too extensive for review and discussion here.

Two patents to Coignet, both issued in 1869, and the one issued to Hinckley, issued in 1899, are cited against all of complainant's patents. A number of other patents are cited by the defendant, some against one of the complainant's patents and some against another. They will not be applied in detail. They consist of one to Cunningham, 1907, four to Parmley, three in 1902 and one in 1904; two to Hennebique issued in 1898, in which the reinforcing bars in beams or girders are shown continuous as one rod in their lower longitudinal part, upwardly deflected part and longitudinal part in the upper surface, and in the specification he says: "It is possible to construct girders resistant in all their parts in a perfect manner to the effects of tension, the effects of compression, the breaking effects and the bending effects, while reducing to a minimum the quantity of iron employed and suppressing or dispensing with iron in the part under compression." There as here, the tension rod in all of its parts rests in the one perpendicular plane. And also patent issued to Sission and Wetmore (No. 124,453) in March, 1872. Hennebique appears to have completely covered all that was inventive in Luten's so-called truss or shearing rod patent, No. 979,776.

I see nothing more than mechanical skill in tying the wings and abutments together, the circular kneebrace in the outer girder with a reinforcing member, binding it to the adjacent abutment and girder and in carrying the transverse member in the roadway into the outer side of the upper spandrel or girder and upward and over the longitudinal reinforcing member in that girder. In view of the Coignet letters and of the prior state of the art as evidenced by his patent and the publications introduced as above noted, he made specific claim to a "metallic framework linked or arranged so as to strengthen the same."

The views above expressed make it unnecessary to consider the defense of noninfringement of some of the claims.

The authorities relied upon will not be cited, but briefs in which they have been noted will be placed with the files.

It is ordered that the bill be dismissed at complainant's costs.

ROBERT E. LEWIS,
District Judge.

(Endorsed) 6,129. United States District Court, District of Colorado. Daniel B. Luten vs. George Washburn et al. Opinion, Lewis, District Judge; Filed Nov. 13, 1915.

A Civic Center in Honolulu is being agitated by many citizens. At present Capitol Square has in its center the executive building, and contains also the archives building and a wooden structure known as the Bungalow. It is proposed to raze the latter and to erect in its place a three-story building for the use of the various land departments. In the same square a commission building will be erected to house the many commissions that are a part of the government of the territory. With the executive building as a nucleus, the civic center as proposed would cover several city blocks.

Activated-Sludge Experiments at Urbana, Ill.

One of the most complete of the many experimental activated-sludge plants for the treatment of sewage in the United States, Canada and England is at Urbana, Ill., where it is being operated by Edward Bartow and F. W. Mohlman, of the State Water Survey, University of Illinois. The plant consists of four reinforced-concrete tanks, with the necessary pump and compressed-air supply. Two papers on the design and operation of these tanks were presented before the American Chemical Society, at Seattle, Wash., in September, 1915, by Messrs. Bartow and Mohlman, but were not made available to the technical press until Dec. 1. They extend the information on the Urbana experiments published in *Engineering News* of Apr. 1 and July 22, 1915. Liberal extracts from the two papers follow:

Description of the Four Tanks

Each tank is 3 ft. 2 in. square, giving an area of 10 sq.ft., and is 8 ft. 5 in. in depth above 1½-in. Filtros plates, which are used for diffusing the air. In two tanks there are 9 plates, each 12 in. square, covering the entire floor. In the third tank there are 3 plates, covering one-third the area of the floor, forming the bottom of a central trough. The remainder of the bottom slopes to the plates at an angle of 45°. In the fourth tank is a single plate in the center covering one-ninth the area, with the bottom sloping to it at an angle of 45° from all sides. Below the plates is an air space 4 in. deep. A petcock is provided to relieve the air pressure when draining the tank and to prevent air bubbles from rising and stirring up the sludge. The air obtained from the university compressed-air plant at a pressure of 80 lb. is reduced by a pressure-reducing valve to 8 lb. and is further regulated by a hand-operated valve before passing through meters on each tank. The pressure under which it enters the tank is sufficient only to overcome the pressure of the sewage, equivalent to about 8 in. of mercury or a little less than 4 lb. per sq.in.

Two outlets for the effluent are respectively 2 ft. 6 in. and 5 ft. 7 in. above the porous plates. A tank can be filled in 6 min. and drained to the lower outlet in 8 min.

Review of the Operating Results

Experience has shown that a lower floating outlet would be preferable. A fixed outlet is objectionable because sludge is at times drawn out with the effluent. In fact, no accurate data have been obtained concerning the quantity of sludge formed, because we have been unable to determine how much has been lost with the effluent. In order to prevent this loss, a floating outlet made of 2-in. pipe connected together with loose joints, has been placed in tank C. The effluent flows to the outlet through a screen of copper wire of about 16 mesh, which is fastened on both sides of an iron frame 1 ft. square. With this arrangement no sludge has been lost, and we expect to obtain accurate data concerning the amount of sludge formed from the sewage.

The amount of sludge must be determined by weight on the dry basis, for it has been noted that its volume and rate of settling vary with the amount of air applied. If an unusually large amount of air has been applied, the sludge will settle more slowly and will occupy a much greater volume, even after prolonged settlement, than it does when less air has been applied.

Tanks A and B were filled with the same kind of sewage on May 5, 1915. The sewage in tank A was aërated continuously. The sewage in tank B was aërated 23 hr., allowed to settle, the supernatant liquid withdrawn and tank refilled with fresh sewage in 1 hr. This cycle was repeated daily. Determinations of the amount of sludge and of the degree of purification were made daily.

At the end of 10 days, after 1 hr. settling in Imhoff cones, 1% of the volume in tank A consisted of sludge, while about 10% of the volume in tank B was sludge. The effluents from tank A, which had been aërated 10 days, and from tank B, which had been aërated one day, were equally stable, while that from tank B was clearer.

Tank B was continued in operation, changing the sewage every 24 hr.; after 15 days nitrification was complete. Then the sewage was changed every 12 hr. Nitrification was again complete after 8 days. Then the sewage was changed every 6 hr. Many of the effluents with the 6-hr. cycle were putrescible, and it is necessary at intervals to aërate for longer periods. This comparison indicates, however, that sludge may be satisfactorily activated by changing the sewage before nitrification is completed and that the sewage may be changed at frequent intervals.

Tank A was therefore cleaned and fresh sewage added every 12 hr. Stable effluents were obtained in 7 days. Complete nitrification occurred in 18 days, after which the sewage was changed every 6 hr. The effluents obtained from the tanks during this 6-hr. cycle were not all stable, yet the average improvement was so great that the conclusion is reached that activated sludge may be built up by changing sewage at frequent intervals without complete nitrification of each dose of fresh sewage. A considerable degree of purification is also obtained from the beginning of the operation, and the time for building up adequate sludge for the process is cut down very materially. A later experiment with tank C showed that satisfactory activated sludge could be built upon a 6-hr. cycle.

Diffusion Area That Is Required

Tank C, with 3 sq.ft. of Filtros blocks, gave some stable effluents after 5 days. Tank D, with only 1 sq.ft. of diffusion area, did not give stable effluents in 18 days. The sludge from C was of good appearance, while that from D was not as flocculent and at times had a septic odor. During the comparative experiment an average of 450 cu.ft. of air per 400 gal. of sewage was used with tank C and of 360 cu.ft. of air per 400 gal. of sewage with tank D. The amount of air given tank D was always sufficient to keep the sludge mixed with the sewage. In fact, the sewage in tank D was agitated much more violently than that in tank C. We have concluded that 1 sq.ft. of Filtros plate per 10 sq.ft. of floor area is hardly sufficient.

We have noted that it is quite essential that the plates be as nearly as possible at the same level. A variation of ¼ in. in level will cause uneven air distribution. The distribution seems to become more uniform the longer the plates are used.

The quality of the effluents has usually depended more on the strength of the raw sewage than upon any other variable. The tanks, when operating on a 6-hr. cycle, were filled at 9 a.m., 3 p.m., 9 p.m. and 3 a.m. The strength

of the raw sewage, estimated by the free ammonia values, averages for the 9-a.m. sewage between 20 and 35 parts per million; for the 3-a.m. sewage, between 3 and 12 parts. Nearly all of the 3-a.m. sewages have given stable effluents, but the strong morning sewages have quite frequently given putrescible effluents. Unless the sludge is in good condition and well nitrified, a strong sewage cannot always be purified in 4½ hr. even by increasing the air to 800 cu.ft. per 400 gal. In the normal working of the plant the sludge will usually regain its "activity" if 800 cu.ft. of air is applied for several periods after the strong sewage has been added.

At times, however, with a succession of strong sewages, it is necessary to increase the time of aëration in order to obtain good effluents. When strong sewages are to be treated, a definite cycle of operation cannot be established without provision for longer aëration of the sewage or separate aëration of the sludge. In order to keep the sludge in its most active state, complete nitrification of such sewage is necessary. Effluents are usually stable if 50% of the free ammonia is removed and 2 to 3 parts per million of nitrogen as nitrates are present. A completely nitrified effluent is neither necessary nor economical.

The greatest efficiency in air consumption will be obtained when enough air is used to make the sewage nonputrescible and to keep the sludge activated.

Fertilizer Value of Activated Sludge

The sludge obtained in the process is flocculent, resembling a freshly formed precipitate of ferrous-ferric hydroxide. It separates easily from the clarified water and, after 1 hr. settling, contains from 96 to 98% of moisture. On further standing, about one-half of this water can be removed. The remaining material can be dried by filter pressing or dried on beds of sand and evaporated over steam baths.

The disposal of the sludge can be most easily accomplished if it has manurial value. That activated sludge has manurial value is shown by its chemical composition, by its reaction with various soils and by its effect on the growth of plants. Specimens of sludge obtained at the experimental plant have varied in nitrogen content from 3.5 to 6.4%. The lower values were obtained during periods of high water. Street wash was getting into the sanitary sewers, and since no grit chamber was provided to remove the grit, the nitrogen value of the sludge was greatly lowered. The tests of the fertilizer value have been made on the richer specimens which were first obtained.

Through the courtesy of Paul Rudnick, chief chemist, Armour & Co., Chicago, the availablity, according to the alkaline-permanganate method as used by the New England States, was shown to be below 44.7%. The sludge would be classed as an inferior ammoniate, but the availability according to the neutral-permanganate method, which has been adopted by the Southeastern States, was shown to be 89.0% and would therefore be classed as satisfactory.

Tests have been made by Prof. C. B. Lipman (University of California Bulletin 251, 1915) in which a fertilizer and a soil are incubated for a month. The results obtained were reported by him (in part) as follows:

The activated sludge used contained 6.2% total nitrogen and no nitrate. The hundred grams of soil in every case contained nitrate in milligrams of nitrogen as follows: Anaheim soil, 1.0; Davis soil, 0.3; Oakley soil, 0.1.

The amounts of nitrate produced in one month's incubation from the soil's own nitrogen and from the nitrogen of the sludge mixed with the soil in the ratio of one part of sludge per hundred of soil is, in milligrams of nitrate, as follows: Anaheim without sludge, 6; Anaheim with sludge, 10; Davis soil without sludge, 4.2; Davis soil with sludge, 14; Oakley soil without sludge, 2.2; Oakley soil with sludge, 4.

These figures indicate that the general tendency is to make available the nitrogen of sludge in type soils at about the same rate that nitrogen is transformed into nitrate in such organic nitrogenous fertilizers as fish guano. While it seems to hold a medium position, it nevertheless resembles much more closely in its general characteristics, so far as available nitrogen is concerned, the so-called high-grade organic nitrogenous fertilizers, dried blood and high-grade tankage, etc., rather than the low-grade nitrogenous fertilizers, steamed bone meal, cottonseed meal, garbage tankage, etc.

Although the chemical tests and the nitrification tests with soils indicate that the activated sludge has a high fertilizer value, the final test must be its effect on plant growth. Pot cultures, using wheat, were started in March, 1915, under the general direction of Prof. C. G. Hopkins and with the assistance of J. C. Anderson.

[There follows a detailed account of the results of culture experiments with wheat, lettuce and radishes, as summarized in the concluding sentence of the paper, given just below.]

These pot cultures [wheat] and gardening experiments [lettuce and radishes] show that the nitrogen in activated sludge is in a very available form and that activated sludge is valuable as a fertilizer.

River Improvements at Memphis

The formation of a sandbar covering approximately 40 acres in front of the levee at Memphis, Tenn., has interfered seriously with river traffic at that point and has led to a study of plans for relief. A channel with a maximum depth of 6 ft. and wide enough for the passage of a steamboat is being kept open by the continuous operations of two Government dredges. In the present condition of the river it is not considered feasible to attempt its complete removal by ordinary means.

The city is now considering cutting a 50-ft. channel from Wolf River, which empties into the Mississippi on the Tennessee side at a considerable distance below the bar, so that it will provide a current directly against the bar and scour it away. The land through which the cut would be made is owned by the city and the cost of excavation is estimated at $150,000. This plan was first suggested by Maj. E. M. Markham a year ago, when the formation of the bar was first noticed. Telegrams were recently sent to the War Department asking for immediate relief, but there is little that can be done by the Government at the present time.

The city sewers discharge opposite the bar and the low stage prevents the sewage from being carried off. To eliminate this evil, the city engineering staff is preparing plans for the construction of a new sewer along the wharf to carry the sewage to a less dangerous point.

Col. C. McD. Townsend, Corps of Engineers, U. S. A., President of the Mississippi River Commission, recently announced that the Commission had authorized the immediate appropriation of $75,000 to begin removal of "Mud Island," a 40-acre bar in the Mississippi, directly in front of the Memphis wharf, and which threatens to close the local harbor. It was said that Congress will be asked for $75,000 to complete the work.

Canadian Northern Ry. Opened to the Pacific Coast

SYNOPSIS—Brief description of the physical characteristics of the newest (third) Canadian transcontinental railway. Also gives for comparison the profiles of the Canadian Pacific and Grand Trunk Pacific railways.

The third Canadian transcontinental railway was put in operation on Nov. 22, when the Canadian Northern Ry. ran the first train on its Pacific line from Edmonton to Vancouver, B. C. The second transcontinental line was the Grand Trunk Pacific Ry., opened Sept. 1, 1914, and described in *Engineering News* of Aug. 5, 1915. The first of the transcontinental lines was the Canadian Pacific Ry., opened June, 1886.

The western ends of the three lines are shown in Fig. 1 The Canadian Pacific Ry. runs practically west from Winnipeg, but both of the other and newer lines run northwest from that point in order to develop new territory which had been considered far beyond the probability of settlement when the first line was built. By doing this they were able to get through the barrier of the Rocky Mountains by a pass at a much lower elevation than that adopted by the Canadian Pacific. This is the Yellowhead Pass, and was suggested at one time for the original location of the latter road, but was then rejected as being too far north for a commercial route.

From Edmonton the two newer lines are in close proximity, and through the mountains they are parallel and closely adjacent. When clear of the pass, however, they diverge sharply. The Grand Trunk Pacific continues practically northwest to Prince Rupert, a new city and port not far south of the Alaska boundary. One of the earlier routes proposed for the Canadian Northern was partly along the same general line, following down the North Fork of the Fraser River to the main river and thence south and southwest to a new terminal and port on Bute Inlet, opposite the middle of Vancouver Island.

The adopted route of the Canadian Northern Ry. follows the valley of the Athabasca and Miette Rivers to the summit of the Yellowhead Pass. West from that point it runs along Yellowhead Lake, down the Fraser River (North Fork) for 40 mi. and across the head of Cranberry Lake, beyond which it rises to the Albreda Summit at an elevation of 2,861 ft., or 850 ft. lower than that of the Yellowhead Pass. The line runs down the Albreda River till it strikes the North Thompson, which it follows to Kamloops, then the Thompson River to Lytton and the Fraser River to the coast. From Kamloops the new line practically parallels the Canadian Pacific Ry.

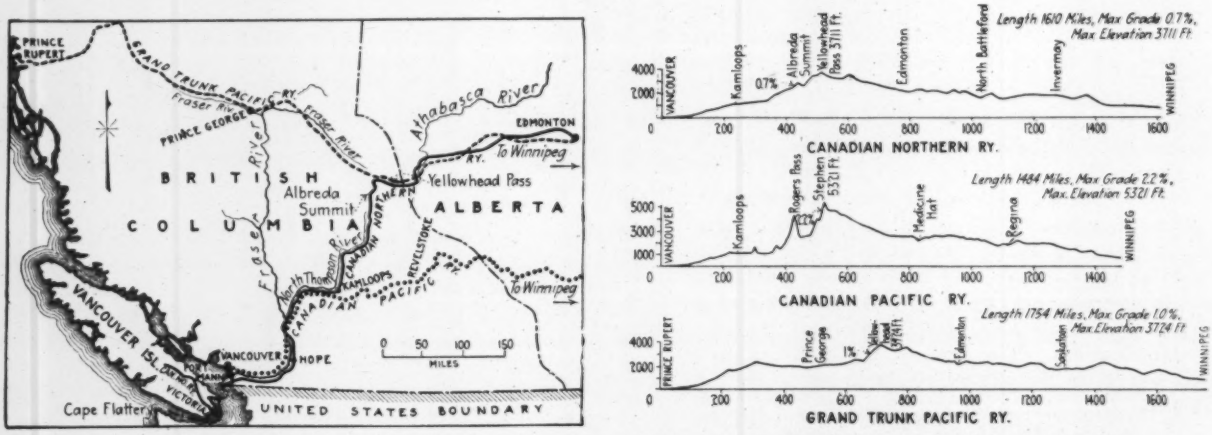
The railway company has established a new city and port at Port Mann, but the line runs beyond this to the older port of Vancouver. From the latter terminal a car ferry will transfer trains to Patricia Bay on Vancouver Island, whence the Canadian Northern has a line to Victoria, the port used by most of the Canadian ocean steamers in the Pacific service. Thus passengers will be able to take train to and from Victoria, instead of using the transfer steamers across the Sound to Vancouver.

PACIFIC COAST SECTION OF THREE CANADIAN TRANSCONTINENTAL RAILWAYS

Railway	Winnipeg To	Miles	Max. Elevation, Ft.	Max. Grade
Canadian Northern...	Vancouver	1,610	3,711	0.7%
Grand Trunk Pacific..	Prince Rupert	1,754	3,724	1.0%
Canadian Pacific.....	Vancouver	1,484	5,321	2.2%*

*Reduced from the original grade of 4.2%.

An interesting comparison of the profiles and operating conditions of the three lines from Winnipeg to the Pacific Coast is shown in Fig. 2, and their main features are given in the table. There is a remarkable difference between the maximum grades of 0.7 and 1% on the new lines and the 4.2% grades of the original location of the Canadian Pacific Ry.; although within recent years the last-mentioned grades have been reduced to 2.2%. The maximum grade of 0.7% on the Canadian Northern Ry. occurs on only one engine division, the remainder of the line having maximum grades of only 0.4 and 0.5%.



FIGS. 1 AND 2. MAP AND PROFILES OF THE PACIFIC COAST SECTIONS OF THREE CANADIAN TRANSCONTINENTAL RAILWAYS

Three views of the characteristic construction on the Canadian Northern Ry., about 40 mi. west of the summit, are shown in Fig. 3. At *A* is a heavy rock cut in a steep

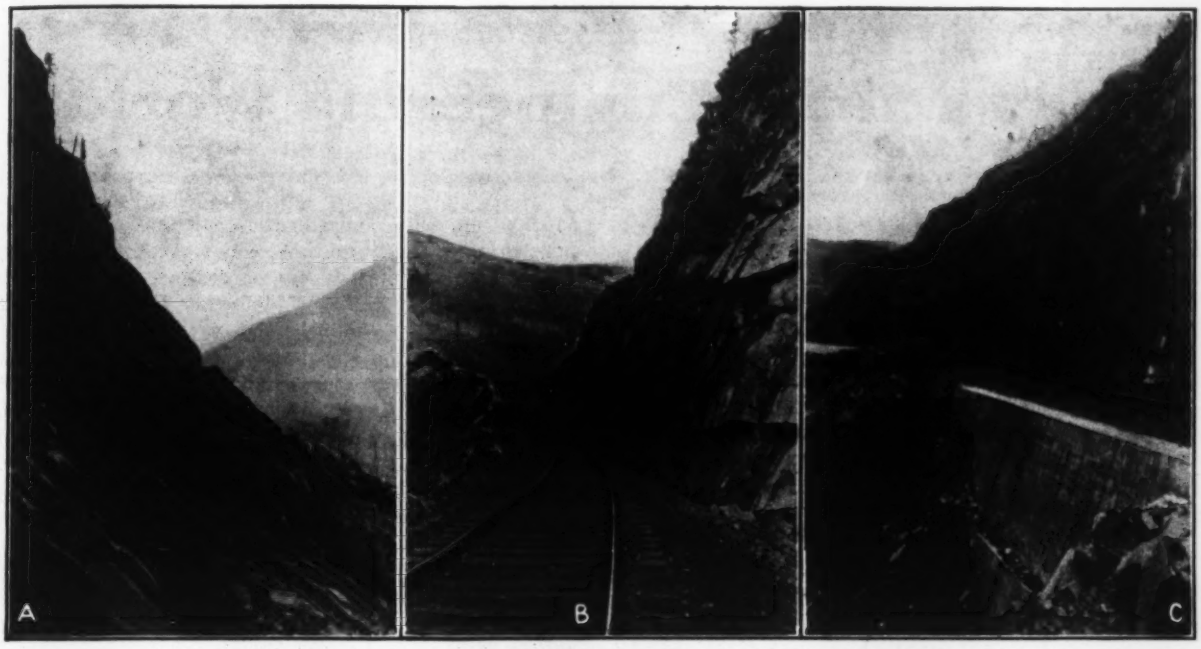


FIG. 3. HEAVY CONSTRUCTION WORK NEAR YELLOWHEAD PASS; CANADIAN NORTHERN RY.

mountain slope. At *B* is a solid rock cut, from which about 43,557 yd. was taken out. At *C* is another rock cut where a heavy concrete retaining wall was required to support the outer side of the roadbed.

The last rail of the Pacific section was laid in January, at a point about 200 mi. from Vancouver. The eastern sections of the new line have been described in *Engineering News* of Apr. 5, 1906; Nov. 9, 1911; June 27, 1912, and July 10, 1913. The bridge over the Thompson River at Kamloops, with a cable-lift drawspan, was described Feb. 26, 1914.

The construction of this new line into the great northwest territory and down to the Pacific Coast has been due to the enterprise of Sir William Mackenzie, president, and Sir Donald Mann, vice-president, of the Canadian Northern Ry. M. H. MacLeod is General Manager and Chief Engineer of the lines west of Winnipeg.

Jacksonville Municipal Docks Nearing Completion

The first stage of the large municipal dock system started by the City of Jacksonville, Fla., over a year ago is now approaching completion. Practically all the filling work has been done, and the pier structures are in such shape that it will be possible to dock boats at them by the beginning of the new year. A manager of terminals has been appointed and the cotton warehouse and compresses are about ready. All that remains to be done is the securing of business to justify the project.

The site of the docks is a tract of 135 acres lying along the St. Johns River at almost the northerly boundary of the city, about 1¼ mi. from the nearest railway and considerably farther from the business center of the town. At present there is nothing in this immediate vicinity but some isolated plants. The work consisted in filling in the site about 6 ft. above mean water with characteristic Florida white sand dredged from the river and building two piers (one with sheds), the connecting railway to the trunk-line roads and a cotton warehouse with compresses.

The filling was all done with hydraulic dredges, about 1,250,000 cu.yd. of sand being moved. The two piers are similar, each 1,000 ft. long and 260 ft. wide, with an intermediate 260-ft. slip. At present the bottom in the slip and off the pier ends is dredged to a 35-ft. depth; but the outer faces of the piers remain at their original lower depth. The St. Johns River has now only about 28-ft. depth to its mouth, but the Federal government has a 35-ft. project under way.

Each pier structure is a central 200-ft. filled section, retained by Lackawanna steel sheetpiles tied together by rods across the 200-ft. width, with a 30-ft. timber-pile wharf section outside. On the fill will be two one-story steel sheds, each 73 ft. wide, with space between and on either side for sunken railway tracks leading down from the ladder on the onshore fill.

The tracks from this ladder lead back 6,800 ft. over a right-of-way wide enough for the erection of warehouses or factories to the main interchange yard at the trunk-line railway connection. It is the intention of the city to control the movement of all trains inside of this connecting point.

The cotton warehouse comprises a one-story reinforced-concrete building alongside the tracks and two cotton compresses, one to be operated hydraulically and the other by steam.

The cost of the work, about $1,500,000 to date, was defrayed by a bond issue of the City of Jacksonville. The design and construction have been under the direction of an elected body of 15 men known as the Board of Port Commissioners, with Fred W. Bruce as chief engineer.

There are also under construction at Jacksonville the new privately owned docks at Commodore Point, which were described in *Engineering News*, Oct. 21, 1915, p. 772. This system is located about 2 mi. upstream from the municipal docks but nearer the city's business center.

News of the Engineering World

Export Freight Clogs New York Railway Terminals

The unprecedented movement in export freight has caused such a congestion in the railway terminals in the New York City district that several of the railway companies have declared a partial or complete embargo on further receipt of freight for foreign transport. The Delaware, Lackawanna & Western R.R. has placed such an embargo on the export freight from all of its lines, the Pennsylvania R.R. has placed a similar bar on export flour and lumber at New York and on export grain at Philadelphia and Baltimore, and the Baltimore & Ohio R.R. has prohibited iron and steel articles for export through New York. It is reported that 17,000 carloads of freight are held up in and around New York awaiting vessels.

While the terminal facilities at New York are not sufficient to care for the present influx of freight, the real cause of the congestion is the lack of ships to carry it.

Southern Waterways Projects

Conventions of three Southern waterways associations were held recently for the purpose of arranging to bring their projects to the attention of Congress at its coming session.

The Tennessee River Improvement Association, which met at Chattanooga Nov. 15 and 16, adopted resolutions asking Congress to provide for the development of power at Muscle Shoals and the establishment of a plant for electrical nitrogen fixation for fertilizer and military use. Government engineers already have plans for this development, it is stated, and the cost was estimated at $16,000,000. The immediate completion of locks and dams at Caney Creek and the selection of one of alternative plans already provided for the improvement of the middle section of the river, with a preference for lock-and-dam construction above channel work, were urged as part of the memorial. The river carried 50,000 cars of freight during the past year, it was stated.

The Arkansas River Development Association met at Little Rock, Ark., and decided to ask for $10,000,000 for the building of a system of dikes, revetments, wing dikes and jetties from the mouth of the Arkansas to the Tulsa District. With an improved river, it was stated, more than 500,000 tons of freight annually could be hauled.

The Cumberland River Improvement Association met at Nashville on Nov. 23 and asked Congress to provide for the construction of locks and dams already planned and to build other necessary works.

The Mississippi River Levee Association will present to Congress a series of photographs of the river. John A. Fox, secretary of the Association, and John K. Milton, photographer of the Illinois Central R.R., are taking a 1,000-mi. trip along the river for this purpose.

Wartime Road Building

The accompanying view is from a photograph recently sent from Europe to illustrate one phase of engineering work in connection with the great war. It shows a party of German military resurfacing a macadam road in northern France. The picture is interesting as showing that the roads at least will not be destroyed by the war, for the only reason, however, that keeping them in prime condition is a military necessity.

WARTIME ROAD IMPROVEMENT IN EUROPE

Municipal Dock for St. Louis, Mo.

Progress is being made on the municipal dock project for St. Louis. Plans for the first section of the dock have been approved by the Board of Public Service, of which E. R. Kinsey is President, and an ordinance authorizing the construction of the dock at a cost of $285,000 has been introduced in the Board of Aldermen. The estimated cost of the dock alone is $255,000, and of equipment $30,000.

The first unit of the dock will be 300 ft. long out of a total length of 1,200 ft. The plans call for a reinforced-concrete structure, including both piling and decks. The dock will be open underneath and riprapped. Provision is made for diagonal pile fenders extending back from each end of the dock and also for a certain amount of levee paving. A railroad track will run down the center of the dock. A steel frame warehouse will be built in back of this track and a crane will run between the track and the water side. The dock will be equipped with two traveling cranes for transferring material between either boats and cars, or between boats and the warehouse. The warehouse and platforms will be equipped with electric trucks, and possibly with tiering machines. The estimated cost of the other three sections of the dock, which will not be put under construction until this section is completed, is $155,000.

The track mentioned above will connect directly with the municipal railway which the city took over from the terminal company at the expiration of its franchise this year. The city now has through tracks extending from a point south of the municipal bridge to the northern city limits.

In connection with this dock enterprise it may be mentioned that after a recent brief promotion campaign by the St. Louis newspapers shippers of that city have guaranteed over 160,000 tons of freight for the proposed Mississippi River barge line out of St. Louis.

An Explosion and Fire in the pumping station at Manchester, Mass., on the night of Nov. 23, wrecked the building, putting the plant out of commission and causing damage estimated at $10,000. The pumping station was one-story high, built of brick with concrete floor, and it housed a 250-hp. producer-gas engine, which was used to pump water from Gravelly Pond to the water tower. The accident will not interfere with the town's water-supply, as there is an independent system of artesian wells that will serve until the plant can be replaced.

A Health-Insurance Act for introduction in the various state legislatures of the country has been drafted in tentative form by a committee of the American Association for Labor Legislation (131 East 23d St., New York City). The bill provides that all manual workers and others earning less than $100 a month shall be insured against sickness, half the estimated cost of the insurance to be paid by the employers. An explanatory pamphlet may be obtained by addressing the association.

A State Health Association has been planned for Connecticut. The movement was started at a complimentary dinner to Prof. C.-E. A. Winslow in New Haven on Nov. 18. It was voted to have Dr. E. J. Root, of Hartford, Chairman of the State Board of Health, name a committee of four to perfect the plans. The purpose of the organization is to promote concerted and uniform action among health associations, and otherwise assist in the improvement of health conditions throughout the state.

Experimental Activated-Sludge Plants are being built at Chicago by Sulzberger & Sons Co. and by Armour Co. It is stated that at a recent conference of engineers and chemists representing the Chicago packing-house interests much enthusiasm was shown for the activated-sludge process, and that some even went so far as to declare that this is the only process of sewage treatment brought to their attention which gives promise of satisfactorily treating the liquid wastes from the packing houses and at the same time recovering the valuable material which they contain.

A Dexter Brackett Memorial Prize was the recommendation of the committee of the New England Water-Works Association, adopted at the Nov. 10 meeting held in Boston. A bronze medal to be known as a Dexter Brackett Medal is to be awarded annually for the most meritorious paper presented to the association. Enough members have already guaranteed a sufficient sum to assure the success of the plan. It was voted at the meeting that the same committee (Frederic P. Stearns, Allen Hazen and Alfred D. Flinn) be requested to draft a letter to be sent to the entire membership, offering each an opportunity to subscribe.

The Ship-Canal Route Across New Jersey surveyed by the Federal Government a few years ago is to be permanently marked by the New Jersey Board of Commerce and Navigation. A survey party is now engaged in placing monuments along the center line. The canal is to extend from Bordentown, on the Delaware River, to Morgan, on Raritan Bay—about 33 mi. The State is to purchase the right-of-way for the canal, according to a resolution of the New Jersey Legislature in 1911. The type of canal recommended by a special board of army engineers was a sea-level canal of 25 ft. depth and 125 ft. bottom width. The estimate of cost was $45,000,000.

The Boundary Line between the states of Ohio and Michigan has been fixed after a dispute dating back to 1837. The disagreement has involved the jurisdiction of a point of land jutting out into Lake Erie, about three miles from Toledo, known as Point Place, a summer suburb of Toledo. The terminus of the Ohio-Michigan line on the point has been established by federal government surveyors and a monument erected. Here on Nov. 24, standing in their respective states, the governors of Michigan and Ohio shook hands across the line, made speeches and otherwise celebrated the event. The engineering societies of the two states took a prominent part in bringing about a settlement of the dispute.

The Law Prohibiting Alien Labor on Public Works in New York State was upheld by the United States Supreme Court on Nov. 29, thus affirming decisions of the New York Court of Appeals and the Court of Special Sessions of New York City. The cases arose in connection with New York subway contracts, the suspension of which was threatened until the legislature amended the law to permit the employment of aliens when citizens were not available. The Supreme Court declared in effect that New York State may "control the construction of its own works and the distribution of its own moneys," and may exercise the same control over cities. It also held that the legislation was beyond Federal control and that it did not violate the provisions of the treaty between the United States and Italy.

The Water-Works Reservoir at Aberdeen, Wash., settlement in one of the banks of which was noted in "Engineering News," Nov. 25, 1915, p. 1054, should not be filled to a depth of more than 10 ft., according to recommendations by R. H. Thomson, Consulting Engineer, Seattle, Wash. Mr. Thomson states that the embankment has settled from 2½ to 3 in. and that some of the support to the slope wall has given away and several small cracks opened in the coping of the reservoir. He recommends that careful measurements of the settlement in the embankment be kept and also in the filled ground to the north of it. Next summer, Mr. Thomson states, it may be desirable to build a heavy concrete wall across the toe of the embankment north of the reservoir, and it may be necessary to terrace the slope to prevent further sliding. If the wall is built it should be carried to rock.

Parkersburg Suspension Bridge—The new suspension bridge over the Ohio River being built by the Parkersburg-Ohio Bridge Co. at Parkersburg, W. Va., is progressing favorably. The bridge consists of a suspension structure 1,425 ft. long (main span, 775 ft.; side spans, 275 and 375 ft.), a 200-ft. simple span at the Parkersburg end, and approaches, the total length being 2,850 ft. It will carry two interurban tracks and a roadway. Work began Mar. 15, 1915, on the piers. By July 1 the substructure was completed, 13,000 cu.yd. of concrete having been placed; the contractor was the Dravo Contracting Co., of Pittsburgh, Penn. At the present time the suspension cables have been built up and wrapped, and erection of the stiffening trusses and floor system is under way. The American Bridge Co. is fabricating the steelwork; the Pittsburgh Construction Co. is doing the erection. Herman Laub is Consulting Engineer to the owners.

Panama Slide Excavation—Excavation of the Culebra slides is going on at the rate of about 250,000 cu.yd. per week. In October the total amount taken from the slides was 872,-

952 cu.yd., according to the "Canal Record." Elsewhere in Gaillard Cut about 200,000 cu.yd. was excavated, making the total excavation for the month 1,079,663 cu.yd., which is 27,000 yd. higher than the September excavation, 88,000 yd. higher than the August excavation and 387,000 yd. higher than the July excavation. The new 15-yd. dipper dredge "Cascadas" was completed on Oct. 30 and started to work on Oct. 31. A remarkable record was made in assembling the dredge, the entire work being completed in a little over seven working days. This compares with 14 days for the "Paraiso" and 30 days for the "Gamboa." Work was facilitated by using picked men and by the ability of the 250-ton crane "Ajax" to handle the heavy parts. The new dredge has not yet worked into good condition, according to last reports of the "Canal Record." In the week ended Nov. 9 it excavated 38,235 cu.yd., as compared with 60,325 for the "Paraiso' and 73,155 cu.yd. for the "Gamboa," both of which are also 15-yd. dipper dredges, though they are slightly narrower in the beam and have only two boilers in place of three of the "Cascadas."

PERSONALS

Mr. Thomas E. Donnelly has been appointed Commissioner of Public Works of the City of Cincinnati, Ohio.

Mr. B. H. Rader has been appointed Western Sales Manager of the Lehigh Portland Cement Co., Chicago, Ill.

Mr. Harold M. Scott has been appointed Assistant Secretary of the Lehigh Portland Cement Co., with headquarters at Chicago, Ill.

Mr. A. Q. Dufour will be in charge of the new branch office of the Jeffrey Manufacturing Co., Columbus, Ohio, in the M. & M. Building, Milwaukee, Wis.

Mr. Claude E. Cox, recently Assistant Valuation Engineer of the Chicago, Milwaukee & St. Paul Ry., at Chicago, has been appointed Engineer of Estimates of the Chicago Union Station Co.

Mr. Ray Palmer, Assoc. Am. Inst. E. E., formerly Commissioner of Gas and Electricity of Chicago, has been elected Vice-President and General Manager of the New York & Queens Electric Light and Power Co., Long Island City, N. Y.

Mr. Elihu C. Church, M. Am. Soc. M. E., Consulting Engineer, and former Secretary of the Department of Water Supply, Gas and Electricity of the City of New York, has been appointed Deputy Warden of Sing Sing State Prison, Ossining, N. Y.

Messrs. William Cooper Proctor, E. W. Edwards, William A. Hopkins, Edward H. Dornette and Christian Schott, all prominent in the civic and commercial life of Cincinnati, have been selected members of the new Rapid Transit Commission of that city.

Mr. C. W. Reinhardt, formerly chief draftsman with "Engineering News," has severed his connection with the Reinhardt-Winters-Cahill Co., Technical Illustrators, Times Building, New York, and has opened an office at 9 Church St., New York City.

Mr. J. P. Hickey has been made Manager of the Standard Engineering and Construction Co., 442 Montgomery St., San Francisco. Mr. William Reinhardt, Assoc. M. Am. Soc. C. E., formerly Assistant City Engineer of San Francisco, is also associated with the company.

Mr. W. N. Royall has resigned as General Manager of the Atlantic Coast Line Ry. on account of ill health. He will be succeeded by P. R. Albright, Assistant General Manager. Mr. J. C. Brand, Superintendent of the Third Division, at Jacksonville, will become Assistant General Manager.

Mr. Elliott H. Whitlock, M. Am. Soc. M. E., Consulting Engineer, has been appointed General Superintendent of the Sandusky Portland Cement Co., with headquarters in the Engineers Building, Cleveland, Ohio. Mr. Whitlock was formerly associated with the National Carbon Co.

Mr. J. H. Weed, Maintenance-of-Way Inspector of the St. Louis & San Francisco R.R., has been appointed Roadmaster of the River and Cape division of the road. Messrs. C. R. Gray, Jr., and H. R. Irvine, Maintenance-of-Way Inspectors have been appointed Roadmasters of the Western division.

Capt. William S. Smith, Engineering Officer at the Philadelphia Navy Yard, has been attached to the Bureaus of Construction and Repair, Steam Engineering and Ordnance, of the Navy Department, Washington, to pass upon suggestions now being received in great numbers concerning the development of the naval service.

Mr. A. H. Markwart, Assoc. M. Am. Soc. C. E., of the firm of Galloway & Markwart, has received an appointment from the Panama Pacific Exposition Co. to superintend the removal of the Exposition buildings under the Director of Works. Mr. Markwart has been Assistant Director of Works of the Exposition, and had much to do with the design and construction of the buildings.

Mr. Carl M. Bernegau, Vice-President and Treasurer of Keuffel & Esser Co., was given a dinner by the firm on Nov. 16, attended by about 500 employees, in celebration of the 25th anniversary of his connection with the company. Mr. Bernegau came to this country from Germany in 1890 and entered the employ of the company in the capacity of bookkeeper.

Mr. E. F. Cykler, Jun. Am. Soc., C. E., formerly Chief Assistant Engineer for H. J. Brunnier, Consulting Engineer, of San Francisco, has been appointed Chief Engineer of the Lord-Young Engineering Co., Ltd. Mr. Cykler's headquarters will be in the Pantheon Building, Honolulu, T. H., in which city and Hilo the company at present has underway about $800,000 worth of work.

Mr. Jacobus Kappeyne, who has been in the Valuation Bureau of the Public Utilities Commission of the District of Columbia, at Washington, D. C., has been appointed Engineer of the Commission. He succeeds Mr. H. C. Eddy, who has been asked to make an electrolysis survey of the District in conjunction with the work of the Commission. Previous to his work in Washington, Mr. Kappeyne did important work in New York for the Public Service Commission in the valuation of street railways.

Mr. Leon S. Moisseiff, M. Am. Soc. C. E., has opened an office for the practice of consulting civil engineering at 69 Wall St., New York City. Mr. Moisseiff has until recently been connected with the Department of Bridges of the City of New York, as Chief of the Division of Design. His more important work includes the design of the Manhattan bridge, the Queensboro bridge (before its modification), the proposed Henry Hudson Memorial Bridge, and also the planning and execution of the work of strengthening the Williamsburg bridge.

Dr. Ernest Fox Nichols has resigned as President of Dartmouth College to accept the chair of physics at Yale University. In their statement announcing Dr. Nichols' retirement from the Presidency, the Trustees said "In seven years he will have made what might well be considered a lifetime's contribution to the well-being of Dartmouth. By unremitting labor he has accomplished a monumental task. Hence he has earned the right to return to his first and chosen field of activity where large honors still await him." Previous to his presidency at Dartmouth, Dr. Nichols held professorships at Colgate University, Dartmouth and Columbia University.

Mr. E. A. Howard, for the last 15 years Land and Industrial Commissioner of the Chicago, Burlington & Quincy R.R., has been appointed Vice-President of the road in charge of all lands and industrial affairs of the company. He is also Chairman of the Joint Board for the construction of the new Union Railroad Station at Chicago. For several years Mr. Howard was Indian Commissioner in Arizona during President Cleveland's administration, and later was a national bank examiner. On entering the railroad business in the Northwest he was associated with Mr. James J. Hill in the construction and extension of railroads through several Rocky Mountain states and to the Pacific Coast.

OBITUARY

Gustave Reinberg, Vice-President of the McKiernan-Terry Drill Co., New York City, died at his home in that city Nov. 22, in his 58th year.

J. B. Wilson, formerly County Engineer and City Engineer at Walla Walla, Wash., at the time the city water system was installed, died Nov. 13 at Montour, Idaho. For the past four years Mr. Wilson had been engineer for a company which was developing an irrigation project on the Payette River.

Charles Abbott Locke, M. Am. Soc. C. E., died at his home in Nashville, Tenn., Nov. 5. He was born near Summerville, Tenn. His first large engineering work was in 1885, when he was placed in direct charge of improvement work on the Cumberland River. After leaving the service of the government, he engaged in consulting work, during which he did much geological prospecting in the South. As advisor to Philadelphia interests he helped to develop the cement industry of Virginia. Mr. Locke was also advisor to the Louisville & Nashville R.R. in connection with the development of the phosphate fields of Tennessee. Mr. Locke retired from practice a number of years ago.

Herbert Merrill Wheeler, Engineer of Electrical Distribution of the Chicago Surface Lines, died in that city Nov. 5. He was born in Shawano, Wis., in 1876 and at the age of 20 graduated in electrical engineering from the University of Minnesota. For several years he was in the employ of the Fort Wayne Electric Corporation and the North Chicago Street R.R. Co., and one time was instructor of mathematics at Lewis Institute, Chicago. He was appointed Electrical Engineer of the Chicago Railways Co., on its organization in 1907, afterward becoming Assistant Chief Engineer. When the street railway system of Chicago was taken over by the Chicago surface lines, in 1914, he was appointed to the position which he held until his death.

Alexander Beith McDonald, M. Inst. C. E., for 25 years City Engineer of Glasgow, Scotland, died at his home in that city Oct. 31. Mr. McDonald had been in the service of the Glasgow Corporation for 45 years, and retired from the position of City Engineer on a pension last year. He was born in Stirling, Scotland, 68 years ago and was a graduate of the Stirling High School. After graduation he was apprenticed with Smith & Wharrie, Civil Engineers, of Glasgow, and ultimately became Senior Assistant of the firm. While engaged in practical work he studied engineering at the Glasgow University, and finally received an appointment on the engineering staff of the Glasgow Corporation under John Carrick, who held the offices of City Architect and Master of Works. One of the greatest pieces of engineering work for which Mr. McDonald was responsible during his connection with the Corporation was the Glasgow Main Drainage Scheme.

ENGINEERING SOCIETIES

COMING MEETINGS

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
Dec. 7-10. Annual convention in New York. Secy., Calvin W. Rice, 29 W. 39th St., New York City.

AMERICAN ASSOCIATION OF ENGINEERS.
Dec. 10 and 11. Convention in Chicago. Secy., Arthur Kneisel, 29 South La Salle St., Chicago.

ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS.
Dec. 13-15. Annual meeting in New York. Secy., Percy H. Wilson, Bellevue Court Bldg., Philadelphia, Penn.

SECOND PAN-AMERICAN SCIENTIFIC CONGRESS.
Dec. 27-Jan. 8. Washington, D. C.

AMERICAN CIVIC ASSOCIATION.
Dec. 28-31. Annual convention in Washington, D. C. Secy., R. B. Watrous, Union Trust Bldg., Washington, D. C.

SOCIETY OF CONSTRUCTORS OF FEDERAL BUILDINGS.
Jan. 3-6. Seventh annual convention in Washington, D. C. Secy., C. R. Marsh, Brattleboro, Vt.

MONTANA INSTITUTE OF MUNICIPAL ENGINEERS.
Jan. 17-19. Annual meeting at Billings, Mont. Secy., C. C. Widener, Bozeman, Mont.

NATIONAL DRAINAGE CONGRESS.
Jan. 19-21. Annual meeting, Cairo, Ill. Vice-Pres., Edmund T. Perkins, First National Bank Bldg., Chicago.

ILLINOIS CHAPTER: AMERICAN WATER-WORKS ASSOCIATION.
Jan. 25-27. Annual meeting, University of Illinois, Urbana. Secy., Dr. Edward Bartow, Urbana, Ill.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 26-28. Annual meeting, University of Illinois, Urbana, Ill. Secy., E. E. R. Tratman, Wheaton, Ill.

NINTH CHICAGO CEMENT SHOW.
Feb. 12-19. First Infantry Armory and Coliseum. Secy., R. F. Hall, 208 South La Salle St., Chicago.

SECOND NATIONAL CONFERENCE ON CONCRETE ROAD BUILDING.
Feb. 15-18. At Chicago. Secy., J. P. Beck, 208 South La Salle St., Chicago.

AMERICAN ROAD BUILDERS' ASSOCIATION.
Feb. 22-25. Annual convention in Pittsburgh. Secy., E. L. Powers, 150 Nassau St., New York City.

The Western States Reclamation Convention is in session at San Francisco, Calif. It is proposed that at a later date an Eastern conference will be held.

Iowa Section of the American Water-Works Association—The first annual meeting of this section is being held Dec. 3 to 4, at the State University of Iowa, Iowa City.

The New England Water-Works Association holds its December meeting at the Hotel Brunswick, Boston, on Dec. 8. The papers to be presented are: "Causes of Explosions of Domestic Boilers"; "Some Water-Works Experiences," and "The Middleboro, Mass., Reinforced-Concrete Tower Tank." Members and guests are requested to register at once.

Boston's New High-Pressure Water-Works for fire service can now be used in case of emergency, states Edward S. Murphy, Commissioner of Public Works, by connecting fireboats with the 6 mi. of mains already laid. It is hoped that a site for the pumping station may soon be found that will be acceptable to the United States engineer officers.

American Society of Mechanical Engineers—The annual convention will be held in New York City Dec. 7 to 10. Dr. John Brashear, president of the society, will make the opening address on Tuesday evening, Dec. 7. The nominations for officers are: President, D. S. Jacobus; vice-presidents, Wm. B. Jackson, J. Sellers Bancroft, Julian Kennedy; managers, John H. Barr, John A. Stevens, H. deB. Parsons; treasurer, Wm. H. Wiley.

The Kansas Good-Roads Association, assisted by the Kansas Good-Roads Federation, will hold its fifteenth annual meeting at Arkansas City, Kan., on Dec. 9 and 10. The program will include papers and addresses on methods of construction, on financial matters and procedure, on the attitude of the state toward road improvements and on the best methods of supervision. Much road work is now being considered for the coming year and this meeting should be well attended.

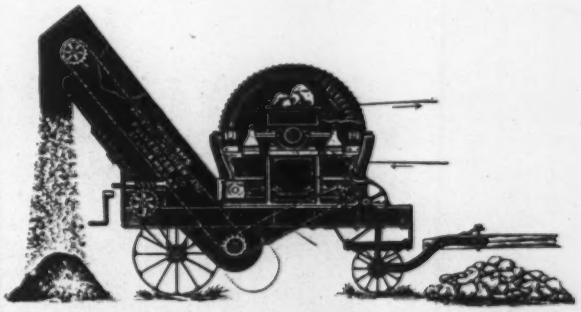
Washington Society of Engineers—The tenth anniversary of the organization of the society was celebrated on Nov. 23, 1915, by a dinner, to which the members of the Naval Consulting Board of the United States were invited as special guests. The main address was by W. L. Saunders, of the board, who spoke on the necessity for military preparedness being assured by a preliminary industrial preparedness. George R. Putnam, Commissioner of Lighthouses, is president of the society.

American Association of Engineers—The Chicago Chapter reently held a meeting at which a set of by-laws was adopted. The following 14 standing committees are provided for: By-Laws, Meetings, Program, Entertainment, Initiation, Finance, Inspection Trips, Publicity, Articles for Publication, Membership, Visiting, Grievances, Local Legislation and Employment, and Information. Chapters are being formed at Springfield, Ill., Minneapolis and Indanapolis. There will be no initiation fee until 500 members have been obtained, after which an initiation fee of $2 will be charged, the fee to increase with each 500 new members. Junior membership will soon be instituted.

Appliances and Materials

Chain-Hammer Crusher for Road Work

Chain-hammer crushers and pulverizers made by the Williams Patent Crusher and Pulverizer Co., St. Louis, Mo., have been used for ore and for agricultural limestone for a number of years, and quite recently this type of crusher has been proved adaptable to macadam-road work, especially where only the softer stones, such as limestone, are used. This type of crusher produces a larger proportion of the finer screenings, but in the case of limestone the screenings have a ready market for agricultural purposes. The crusher is built of



CHAIN-HAMMER STONE CRUSHER FOR ROADBUILDING

two simple elements—a revolving cylinder with hammers attached to the chains, the reach of which is adjustable, and a revolving cylindrical screen. A belt drive operates both parts: the hammers revolve in one direction and the screen in the opposite direction. The only change necessary to convert an agricultural limestone crusher to road purposes is to replace the fine screen with a coarser one. The elevator

attachment shown in the illustration may be thrown out of gear and the product discharged on the ground if desired. An 8- to 10-hp. chain-hammer crusher with a cylinder 30 in. in diameter and 24 in. long is claimed to crush 5 to 6 tons of road-surfacing material an hour. The weight of the outfit (exclusive of power) is about 5,000 lb.

* * *

New Heavy-Duty Edison Storage Battery

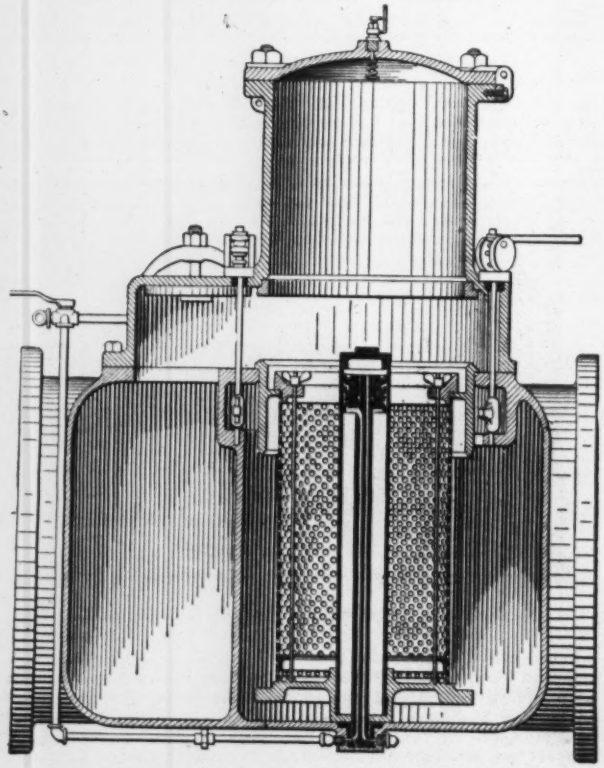
A new design of the nickel-iron alkaline electric-storage battery developed by Thomas A. Edison has been produced for the heavy service of electric locomotives, submarine vessels and electric station emergency service. The reactions employed remain the same as in the smaller cells which have been made for some time by the Edison Storage Battery Co., of Orange, N. J. The positive element consists of alternate layers of nickel hydrate and metallic-nickel flakes packed in small perforated steel tubes. Twenty of these are clamped in a subgrid which is welded into a main-grid frame of steel. The negative material is iron oxide and mercury packed in flat, perforated, rectangular pockets of nickel-plated steel—16 to a main grid. The main grids of both positive and negative plates are three subgrids wide and five or six high. In assembling the plates, hard-rubber strips are secured between adjacent grids. Plates of like polarity are bolted together at neck terminals; hard rubber spacers hold the plates rigid and prevent their touching each other or the steel container. Each pair of subgrids is rated to give 15.6 watt-hr. on a 4.4-amp. discharge rate. The potential is 1 volt.

* * *

Multiple-Basket Condenser Strainers

A development of the multiple-basket type condensing-water strainer built for several years by the Lagonda Manufacturing Co., Springfield, Ohio, is shown in the sketch. The improvement is in the substitution of an air- or water-pressure cylinder for the handwheel and screw stem formerly employed in raising and lowering the baskets.

The straining basket is rigidly supported on a circular base or disk, which also serves as a valve seat when the basket is raised. Attached to the disk is a cylinder of small diameter, the whole moving freely up and down on a piston and piston rod rigidly connected to the strainer body. The piston rod is provided with two conduits, communicating with the upper and lower sides of the piston and connected as shown through a four-way control valve to the pump or compressor supply. When pressure is applied to the top of the piston, the basket is raised to the cleaning chamber. The basket support, or lower valve seat, engages the sliding-valve collar of the strainer, carrying it up with the basket, completely to close the cleaning chamber or bonnet. For assurance against possible leakage or chance lowering of the disk while a basket is removed, there is supplied a cam-lever locking device on either side of the strainer bonnets, as shown. In the flange cap a petcock is provided for relieving any pressure in the cleaning chamber, so that the hinged flange cap can be easily unbolted and opened for the quick removal of the basket. With the basket reinserted and the flange cap bolted down, the basket is lowered into position by releasing the locking device and throwing the handle of the four-way control valve.



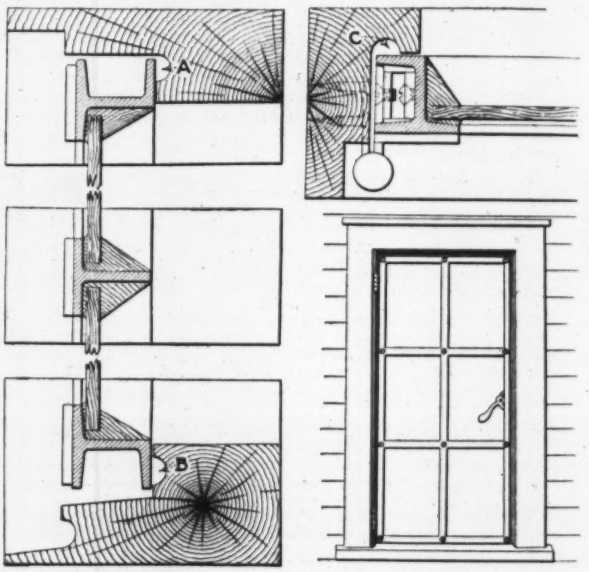
SECTION THROUGH NEW LAGONDA STRAINER

This design of automatically operated strainers is especially suited for power plants and large pumping stations, where the rapidity and ease with which the baskets can be removed and cleaned is essential.

* * *

Steel Casement for Wood Frames

A steel casement for use in wood-frame structures has been designed by E. J. Zahner, of the Zahner Metal Sash and Door Co., Canton, Ohio. It is reported that there has been a large demand for such a casement to eliminate the warping, twisting and binding of wood casements during wet weather.



STEEL CASEMENT FOR WOOD-FRAME STRUCTURES

The construction is shown in the accompanying sketch. The members are electrically welded. This style is furnished in widths up to 2 ft. and in heights up to 5 ft., with any desired arrangement of lights. The construction, as shown, is claimed to be moderately weatherproof and to be wind-tight with felt strips at A, B and C.

* * *

New Line of Batch Concrete Mixers

After several years' experience in the manufacture of continuous concrete mixers the Eureka Machine Co., Lansing, Mich., has placed a batch mixer on the market. The chief aim in the new design is compactness. The whole machine is mounted on a frame of 5-in. steel channels with steel wheels; a double conical drum, made of boiler plate, is driven by a centrally placed gear and has a power loading device. There are two sets of operating levers, which make it possible to manipulate the drum or loader from either side of the machine. The batch capacity is about 5 cu.ft. The power is supplied by a 3½-hp. vertical gasoline engine. The weight complete is 2,800 lb.

* * *

Electric-Light Unit for Construction Work

The "Little Wonder" portable electric-lighting plant consists of a 1½-hp. gasoline engine directly connected to a ½-kw. dynamo, both mounted on a bedplate. The complete unit, including fuel and water tanks, is 31x13 in., 26½ in. high, with a weight of 260 lb. The current produced, 500 watts, is sufficient for twenty-five 18-cp. tungsten lamps. The power is sufficient to operate small electric drills, pumps, grinders, fans, etc., having motors not over ½ hp. The plant is designed particularly for lighting and cooking purposes in country residences, churches, farms, etc., but is applicable also for use in camps and on construction work. It is manufactured by the Swartz Electric Co., Indianapolis, Ind.

Engineering News

VOLUME 74 DECEMBER 9, 1915 NUMBER 24

Record-Breaking Plate Girders for Nickel Plate R.R.

The largest plate girders built in modern times are being made for the double-track skew crossing of the Nickel Plate over the four-track roadbed of the Illinois Central R.R. at 79th St., Chicago, described in *Engineering News* of Oct. 28, 1915. The work is part of the Grand Crossing grade separation.

The bridge has three lines of girders. The girders of the middle line, which carry the heaviest load, are made deeper than the others—10 ft. 10 in. b. to b. of angles as against 9 ft. 8¼ in. for the outer girders. On account of the sharp skew, five spans are required. The normal span length is 125 ft. 8¼ in. c. to c.; but the end spans contain girders of 130 ft. 6½ in. c. to c. length (131 ft. 9 in. o. to o.) The latter, however, are lighter than the 125-ft. girders of the middle line, which weigh 130½ tons.

The 130-ft. girders are the longest single-span plate girders in use. Heavier girders were used by the New York, New Haven and Hartford R.R. in grade-crossing elimination at Worcester, Mass., two years ago. These are up to 122 ft. long, and the heaviest weighs 170 tons, which is 40 tons more than the Nickel Plate girders.

Structurally, two highly individual features of the bridge are the method of support at the abutments and the method of providing for expansion of the bridge. Longitudinally the five spans are continuously coupled so that they expand as a unit—an arrangement frequently adopted in modern bridge practice.

Ordinary masonry bearings at the abutments would have made the girders of the end spans several feet longer than the clear opening, and as the end spans are the longest the extra length was specially objectionable here, increasing the section and weight of the girders considerably. To avoid this, steel columns are set in the abutment to carry the girder end, the masonry serving merely as earth wall. This construction makes the end support practically identical with the intermediate supports, except that the columns are lighter and are braced by the concrete instead of by diagonals. The layout is shown in Fig. 3.

Structure Expands from Middle Span

The bearings on the two middle bents are fixed. Apparently the expansion in the single 125-ft. length between these bents did not require consideration. The other two bents and the two abutment bearings are expansion bearings. Longitudinal stability of the middle or fixed span is given only by the fixity of the columns on their footings. The railway clearance below does not permit of introducing kneebracing, and the middle span is not framed into the columns but rests on top of the columns, as do the other spans.

The type of expansion bearing is unusual and interesting. No rollers or segments are used. The shoe itself, however, is a rocker shoe to allow for deflection of the girders without canting of the bearing plate.

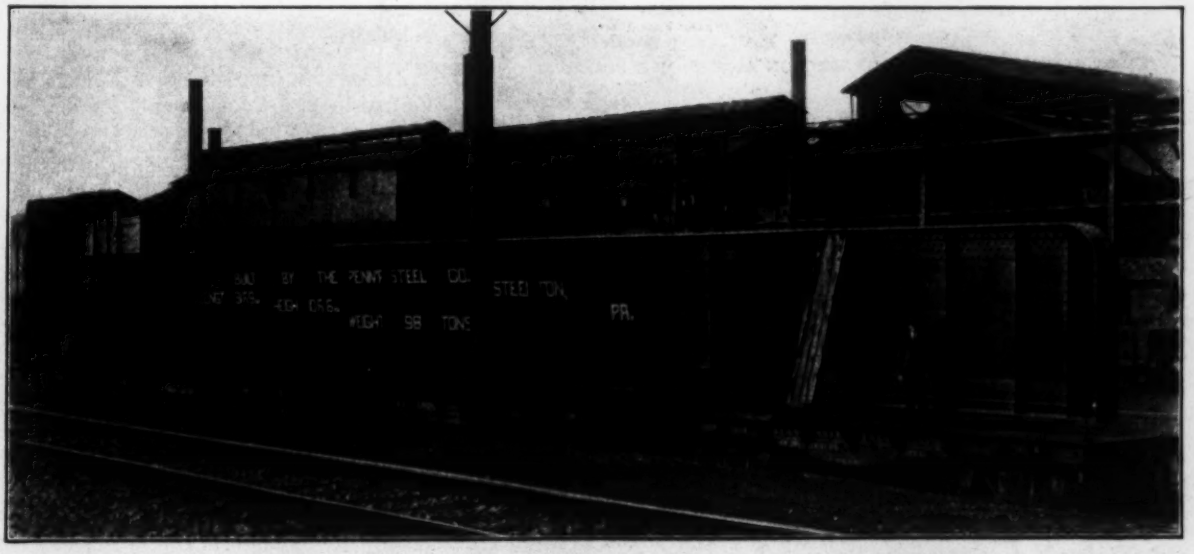


FIG. 1. A 131¾-FT. GIRDER OF THE 79TH ST. BRIDGE, ON CARS FOR SHIPMENT

The rocking seat of the shoe is not made by a pin, as usual, but by the shaping of the two halves of the shoe in the solid metal. The lower shoe plate is a steel casting the upper surface of which carries two semicylindrical convexities, each giving the effect of a half pin laid on the

The make-up of the girders follows standard practice generally. The flanges are made up of a single pair of angles and up to six cover plates, supplemented by a pair of side plates below the angles. Ordinary stiffeners are crimped over the flange angles, but the load-carrying

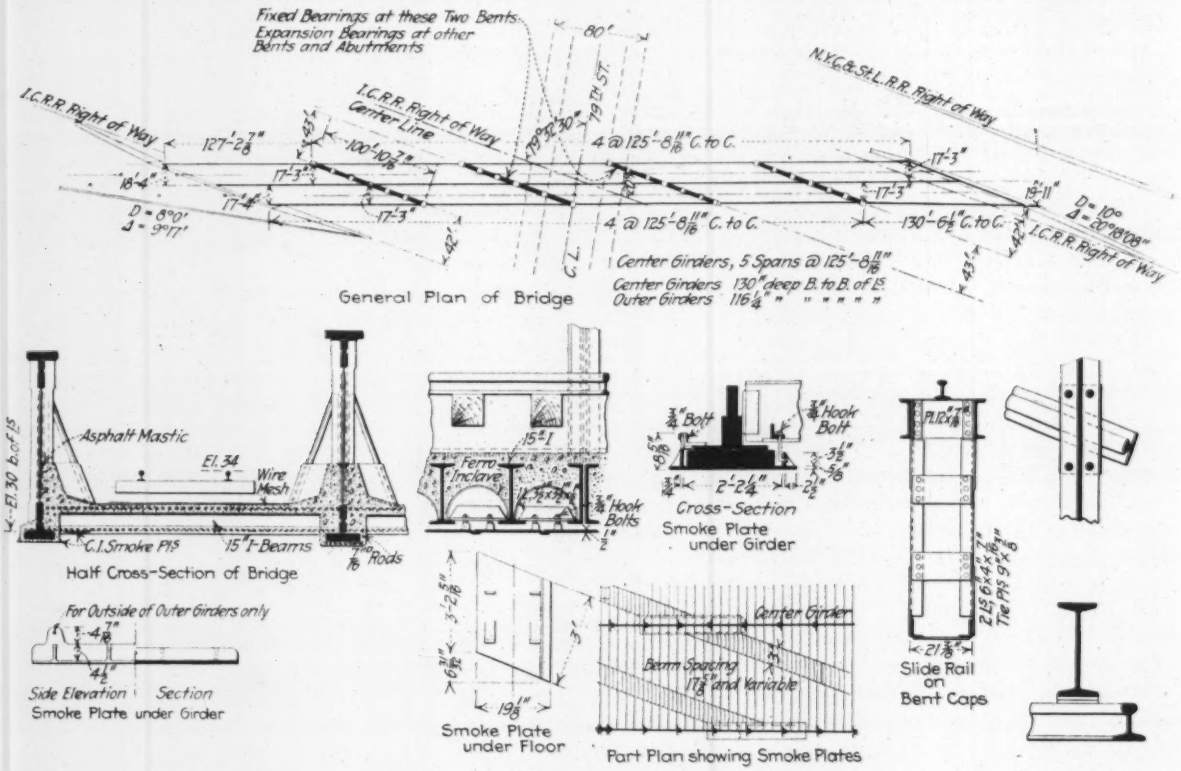

Fixed Bearings at these Two Bents.
Expansion Bearings at other Bents and Abutments
I.C.R.R. Right of Way
I.C.R.R. Right of Way Center Line
N.Y.C. & St.L.R.R. Right of Way
79TH ST.
80'
4 @ 125'-8 11/16" C. to C.
130'-6½" C. to C.
Center Girders, 5 Spans @ 125'-8 11/16"
Center Girders 130" deep B. to B. of Fs.
Outer Girders 116¼" " " " " "
General Plan of Bridge
Asphalt Mastic
Wire Mesh
C.I. Smoke Pl's
15" I-Beams
Half Cross-Section of Bridge
Ferro-Inclave
Hook Bolts
Cross-Section Smoke Plate under Girder
For Outside of Outer Girders only
Side Elevation
Section
Smoke Plate under Girder
Smoke Plate under Floor
Center Girder
Beam Spacing 17⅛" and Variable
Part Plan showing Smoke Plates
Slide Rail on Bent Caps

FIG. 2. LOCATION PLAN AND SECTION AND SMOKE-PROTECTION DETAILS, 79TH ST. BRIDGE OF N. Y. C. & ST. L. RY. AT CHICAGO

plate, one for either of the two spans meeting at the shoe. The girder is seated on this half pin by means of a forged shoe plate bolted to the girder, in which a concave half cylinder is milled. As the concave half cylinder is shorter than the width of the forging, an adequate lateral guiding effect is secured without further attachment.

At the four fixed bearings the lower shoe plate is riveted to the cap plate of the column. At the expansion point

stiffeners over the shoes are left straight and have fillers over the web. The difference in the shaping of the abutment ends and the intermediate ends of the girders is shown by the details in Fig. 3.

A remarkable feature of the girders is that the flange angles are in one piece for the full length, thus eliminating the necessity of splicing the heavy sections. They are 8x8x1⅛-in. angles. These long angles were rolled by the

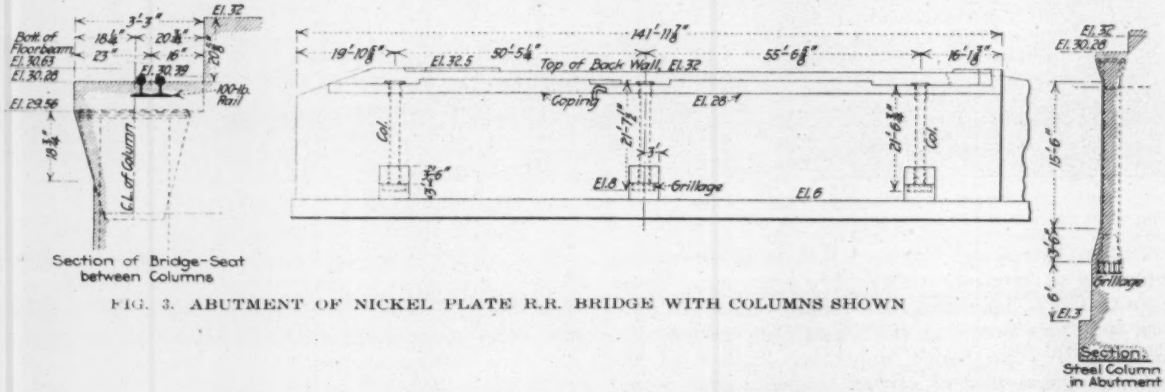


FIG. 3. ABUTMENT OF NICKEL PLATE R.R. BRIDGE WITH COLUMNS SHOWN

it seats on a 1-in. phosphor-bronze slide-plate dropped into a pocket in the column cap, and the shoe plate itself is loosely connected to the cap by means of bolts going through slotted holes.

Pennsylvania Steel Co., Steelton, Penn., which is fabricating the girders and will also erect them. The 129½x ¾-in. web-plates (planed from 130-in.) were rolled by the Lukens Iron and Steel Co., Coatesville, Penn.

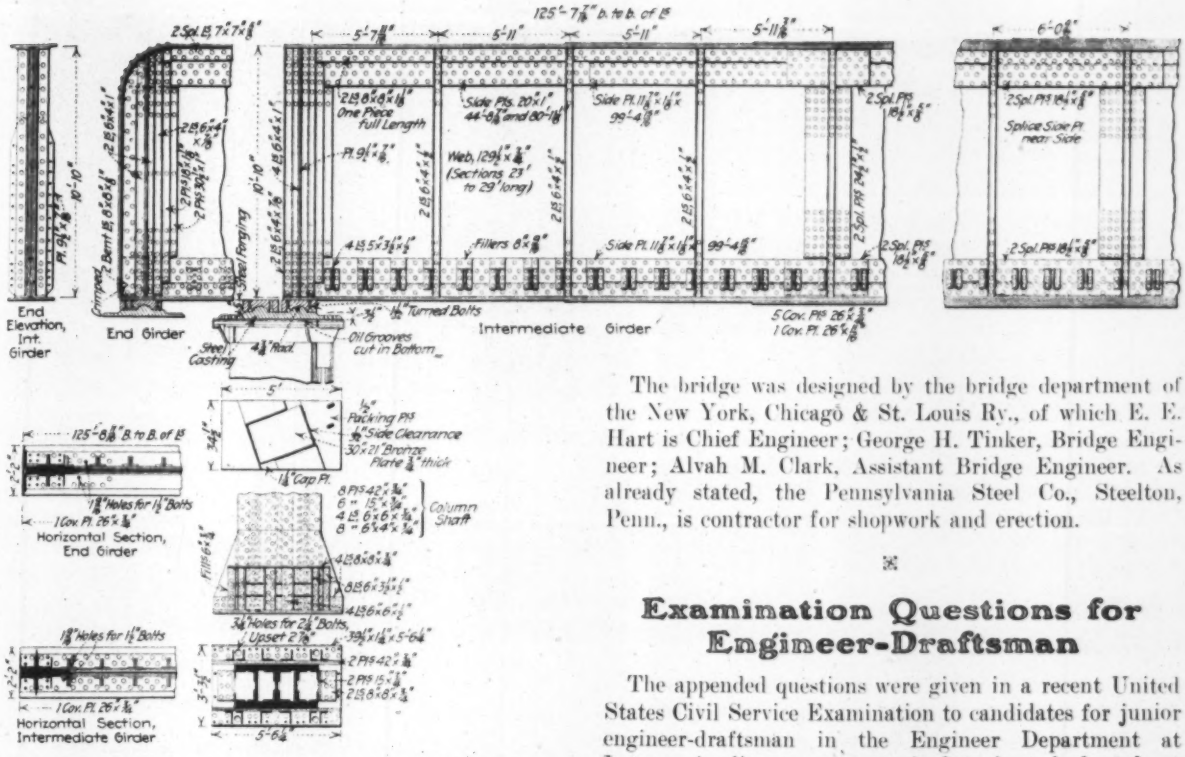


FIG. 4. GIRDER, COLUMN AND ROCKER SHOES, 79TH ST. BRIDGE

The floor (see Fig. 2) is solid, composed of concrete arches on ferro-inclave bent to half-cylinder shape, spanning an average of 18 in. between transverse joists spanning from outer to center girders. The regular joists are 15-in. I-beams, but at each girder stiffener ease of erection made it preferable to use two 15-in. channels.

At the abutment and on the cap girders of the bents the joists are supported by a slide rail, the construction and arrangement of which are shown by sketches in Figs. 2 and 3. At the abutments this support is necessary, but at the intermediate supports it is used solely to improve the deflection conditions and therefore the riding qualities of the track

The bridge floor will carry a regular ballast and tie roadbed. The concrete of the floor is carried up along the side of the girders half way to the top flange, thus making the floor a continuous concrete trough. The trough is drained by pipes directly through the floor, discharging between the Illinois Central tracks. The concrete at its upper edge against the webs of the girders is sealed by a longitudinal strip of asphalt mastic placed in a triangular pocket between concrete and steel.

To shield the bridge against smoke gases and blast action from the Illinois Central trains below, the underside of the floor will be protected with a cement-gun coating, applied after slipping Mitchell-Tappen metal caging over the joist flanges. In addition there will be cast-iron blast plates 3 ft. wide hung directly over the center line of each Illinois Central track. The construction of this cast-iron protection is shown by several sketches in Fig. 2. Cement mortar will be packed behind these smoke plates, covering the angles and bolts which hold the plates and avoiding the formation of any pockets.

The columns will be incased in a concrete wall to a point about 5 ft. above top of rail (Illinois Central).

The bridge was designed by the bridge department of the New York, Chicago & St. Louis Ry., of which E. E. Hart is Chief Engineer; George H. Tinker, Bridge Engineer; Alvah M. Clark, Assistant Bridge Engineer. As already stated, the Pennsylvania Steel Co., Steelton, Penn., is contractor for shopwork and erection.

Examination Questions for Engineer-Draftsman

The appended questions were given in a recent United States Civil Service Examination to candidates for junior engineer-draftsman in the Engineer Department at Large. Applicants were required to have had at least a high-school education and five years' experience as a draftsman. For the examinations familiarity was necessary with calculations, structural details, structural shop practice, reinforced concrete and in making drawings from data.

Use of a structural handbook was permitted. The general subjects and relative weights were: (A) Computations, materials and structural details, 35; (B) drawing and design, 40; (C) training and experience, 25. The time allowed was 7½ hr.

QUESTIONS ON MATERIALS AND COMPUTATIONS

Answer four of the following:

1. Explain in detail two methods of calculating quantities of material dredged.

2. Show a neat pen-and-ink section of a reinforced-concrete beam 10x15 in. by 20 ft. span. Give all dimensions. Make necessary assumptions and calculate safe load per foot of beam.

3. A wall 500 ft. long, 30 ft. high, 3 ft. wide on top and 12 ft. at base is built of 1:3:6 concrete. Specify the number of barrels of cement required and cubic yards of sand and gravel, making no allowance for waste.

4. (a) Calculate the least thickness of metal in a 16-in. c.-i. water pipe under a static head of 150 ft. Allow safe unit stress of 3,000 lb. in metal. (b) A screw has a 1¼-in. pitch; the lever arm is 20 in. and the load is 800 lb. Assuming efficiency as 60%, find the power necessary to move the load.

5. Select a steel column of two channels and two cover-plates riveted to their flanges. The column is of square section and 20 ft. long. The total load on the column is 200,000 lb. Find the least weight of column per foot, using a safety factor of 4.

6. (a) Give a specimen page of level note book showing field notes. (b) State the precautions to be taken in measuring over rough country with a tape.

QUESTIONS IN DRAWING AND DESIGN

Answer two of the following:

1. Determine graphically the stresses in the members of a given roof truss.

2. A sketch showing two water mains of unequal size intersecting at 60°; required to develop the intersection area.

3. Make a sketch of a wharf 120x30 ft. in plan. Draw a pen-and-ink section. Make a bill of material and estimate cost.

Bypass Around Leaky Tunnel in Catskill Aqueduct

By Charles A. Hirschberg*

SYNOPSIS—Driving a bypass tunnel 400 ft. below leaky Moodna tunnel of Catskill Aqueduct. Two 8-in. holes were drilled through 50-ft. concrete plug in surface shaft—one hole for hoisting purposes, the other for chuting concrete for lining of tunnel. Drilling methods.

Driving a shaft and tunnel supplementary to the Moodna pressure tunnel, which connects with the Catskill Aqueduct tunnel under the Hudson River at Cornwall, N. Y., to stop leakage from a damaged section, is practically the last chapter of the gigantic water-supply project of New York City. The work itself is complete now, two months in advance of the time specified by the Board of Water Supply of New York City. There remains only the work incident to tearing out track, cleaning up and sealing the damaged and leaky section. The actual driving and concrete lining of the tunnel and connecting shaft have been finished some time; in fact, the majority of the surface equipment has been boxed and shipped to other work.

The original work was carried on through two shafts, known as No. 7 and No. 8, shown in the profile, Fig. 1. No. 8 shaft formed the connection between the siphon under the river and the main water-supply tunnel and had been permanently sealed. No. 7 shaft was driven as an access shaft and was left open to permit operation of the aqueduct. The cracks which developed in the old tunnel are located near Shaft 8 and extend part way toward Shaft 7.

When it was decided to replace the damaged section the plan adopted was to drive a new tunnel section parallel to the old, but located 400 ft. below it. To save time and expense the contractor was required to utilize Shaft 7 (8 ft. 8 in. in diameter) for handling all materials. This necessitated sinking a supplementary shaft (designated No. 7A), 17 ft. in diameter and 400 ft. deep, from a point within the old tunnel and driving a new tunnel 17 ft. in diameter and 900 ft. long. The latter formed the new connection between the siphon and the main water tunnel. A concrete lining reduced both shaft and tunnel to approximately 14 ft. 2 in. in diameter.

Provision for Handling Materials

The contract was awarded to the Oscar Daniels Co., New York, and the work of installing equipment began in the latter part of November, 1914. Active work on Shaft 7A was not started until Jan. 2, 1915. The time intervening was devoted to installation of the surface plant, placing guides and apparatus for operating a cage in Shaft 7 and driving a dome or upraise over the location of Shaft 7A for hoisting headframe purposes. Preliminary work also included the installation of a platform at a point in Shaft 8 where the new tunnel was to be started.

It was at first thought feasible also to utilize Shaft 8 for handling materials directly from the new tunnel to the surface. This shaft, however, had been sealed at the top by a concrete dome and also by a concrete plug 50 ft. thick and 30 ft. above the old tunnel, so that the idea of using this shaft was abandoned. Blasting operations for the removal of the 50-ft. plug would have endangered the shaft lining. The concrete dome, however, was removed, and the novel idea was conceived of utilizing the portion of Shaft 8 between the new and old tunnel levels by drilling two 8-in. holes through the plug with a core drill. One hole was used for passing the hoist cable

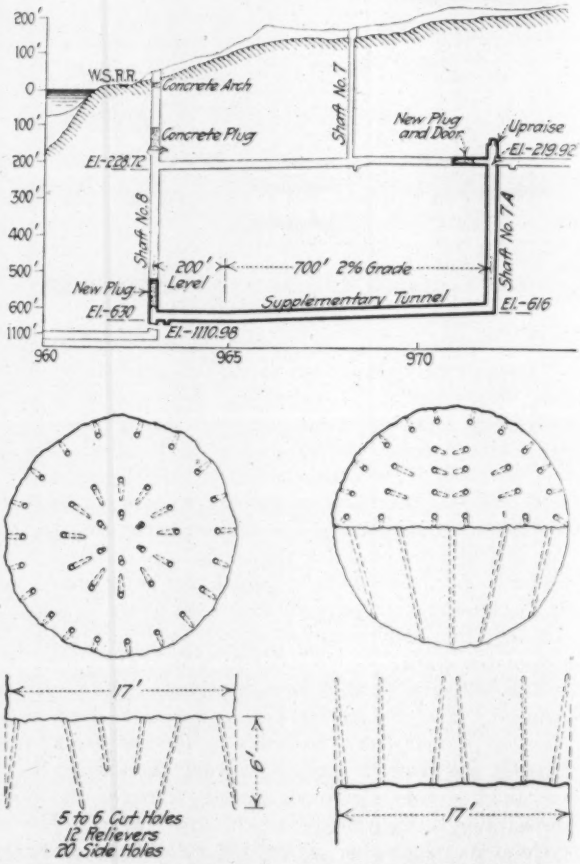


FIG. 1. PROFILE OF OLD AND NEW TUNNEL SECTIONS, WITH DIAGRAMS OF DRILLING ROUNDS

from the surface for handling a cage and the other for chuting concrete for the tunnel and shaft lining.

The tunnel work was prosecuted entirely from Shaft 8. The first round was blasted on Feb. 6, 1915, and the last or breaking-through round on May 20. Driving the tunnel and sinking the shaft were completed at about the same time.

Driving an Upraise

Fig. 2 is a view looking up into the dome or upraise in Shaft 7A. Work in this upraise, which was 17 ft. in diameter and 31 ft. high, was necessarily slow, owing to the need for continual building of temporary staging,

*Ingersoll-Rand Co., New York City.

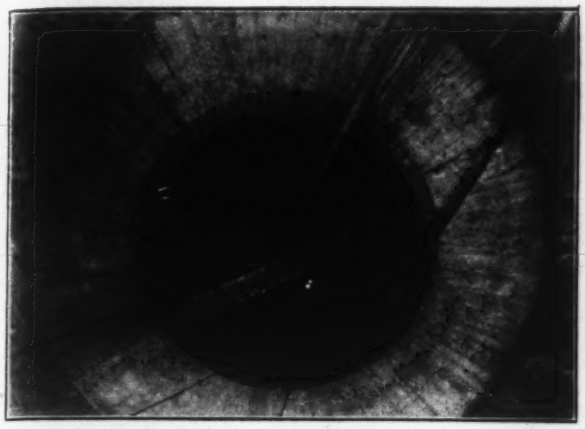


FIG. 2. LOOKING UP INTO DOME OVER NEW SHAFT 7A

which had to be torn out prior to blasting each round. Work was started on Dec. 31, 1914, and was completed Jan. 17, 1915. Three stope drills were employed for the drilling. The dome was concreted to form a setting for the hoisting headframe with its sheaves and to eliminate danger incident to rock sloughing off.

Sinking Shaft No. 7A

In Fig. 1 is a diagram of the drilling round in the shaft. This round consisted approximately of 38 holes. For drilling the shaft as many as six heavy hand hammer drills (Ingersoll-Rand Co. "Jackhamers," Bull Moose size) were employed at one time. The day was divided into one 8-hr. drilling shift and two 8-hr. mucking shifts. All holes were started 2 in. and bottomed 1⅝ in. 1¼ in. powder. The first round in the shaft was blasted on Jan. 22, 1915, and the entire sinking of 400 ft. was completed in 76 rounds, giving an average advance per round of 5.26 ft. After sinking 306 ft., drilling was stopped for 26 days to do concreting, and was resumed again on Apr. 20. In portions of the shaft it was necessary to employ temporary steel lining.

All hoisting in Shaft 7A was handled by bucket, except in the case of the spoil, when the transferable bodies of the 2-ton steel cars were used.

Driving the Supplementary Tunnel

The supplementary tunnel, 17 ft. in diameter and 900 ft. long, was driven by the usual heading-and-bench method. The round (in Fig. 1) consisted of 26 to 28 holes in the heading and five holes in the bench.

Work in the tunnel was started from a platform placed in Shaft 8. The first round was blasted on Feb. 6 and holed through on May 20, during which time 206 rounds were drilled, blasted and mucked, giving an average advance of 4.37 ft. per round. The drilling and mucking may be said to have proceeded simultaneously. The first drilling crew worked from 8 a.m. to 4 p.m. and the second from 8 p.m. to 4 a.m., while the first and second mucking crews worked from 4 p.m. to 12 midnight and from 4 a.m. to 12 noon. Holes in the heading averaged from 7 to 8 ft. deep, and from 6 to 8 ft. deep in the bench. All holes were started 2 in. and bottomed 1⅝ in. Changes of steel averaged 24 in. Four No. 18 Leyner-Ingersoll water drills on two columns were employed in drilling the heading. Two drills of the same type set up on tripods drilled the bench. Each machine was manned by two men. About 150 lb. of 1¼-in. "gelatin" was consumed per blast in the tunnel and 90 to 100 lb. in the shaft.

Air was furnished by two 1,200-ft. motor-driven Imperial air compressors, a pressure of 90 lb. being maintained at the drills. The air was conveyed both to the tunnel and the shaft by means of two 4-in. air lines. Water for the drills was taken from the leakage in the tunnel. All haulage was performed by storage-battery locomotives. Lining the tunnel started after holing through, Blaw steel forms being used. The smoothness of the concrete lining of this work is a feature worthy of note.

Engineers and Contractors

D. E. Baxter and C. L. Ostenfeldt supervised the work for the Oscar Daniels Co., S. A. Knowles being Superintendent. The engineers of the Board of Water Supply were George J. F. Carey, Field Engineer, and W. B. Hoke, Section Engineer. Ralph M. Wheeler, Department Engineer of the Northern Aqueduct, was in charge for the Board of Water Supply under the direction of Alfred D. Flinn, Deputy Chief Engineer, and J. Waldo Smith, Chief Engineer.

FIG. 3. WHERE WORK WAS STARTED ON SHAFT 7A

Note steel forms at point where old tunnel section is to be plugged by a concrete wall fitted with bronze door

A description of the circumstances which led to this repair work, that is the leakage which started the trouble and the then proposed methods of repair, was published in *Engineering News*, Nov. 5, 1914, p. 954.

The Field for Automatic Stream Gages in obtaining records of stream flow is discussed by C. H. Pierce, Hydrographer, U. S. Geological Survey, in the recently published Water-Supply Paper No. 375F. The necessity for automatic height gages has long been recognized, but determination of the proper field for them was not started until 1912. The problem was how to determine whether the conditions at a gaging station were such that two readings a day from an ordinary staff or chain gage gave satisfactory results and what conditions required an automatic gage. The conditions requiring the use of an automatic gage are summarized as follows: (1) regulation of the stream by power development, (2) operation of canals and ditches for irrigation, (3) large and rapid fluctuations due to run-off variations caused by rain or melting ice and snow, (4) inaccessibility of stations or lack of reliable observer, (5) continuous record needed for legal purposes, (6) human fallibility of gage observers. The total number of stations maintained by the Geological Survey in 1913-14 was 1,741, of which 325 stations were equipped with automatic gages.

Gravel Roads of New Hampshire; Patrol Maintenance

SYNOPSIS—Motor tourists during the past summer have generally praised the plain gravel roads of New Hampshire as being ideal. An investigation by one of the editors confirmed this view and led to some conclusions as to how the state highway authorities accomplished such results. Those conclusions, briefly stated, are an efficient patrol system of maintenance and a willingness to spend sufficient money and time and trouble on plain gravel roads to secure results. The patrol system, the most powerful contributing cause, is described in some detail.

The popularity of the White Mountains in New Hampshire for automobile touring has steadily increased during the last few years, and during the recent summer this traffic was extraordinarily heavy. On many main trunk roads automobile traffic averaged from 800 to 1,000 cars a day, and on the Sunday before Labor Day an unofficial count of 1,500 cars was made on the road through Crawford Notch. Even under this excessive traffic, plain gravel roads have stood up remarkably well, and their almost perfect condition all through the season has elicited universal praise and admiration from touring parties, as well as exploded previous theories as to the possible traffic a gravel road could economically carry.

New Hampshire is a sparsely settled agricultural state with a population of less than half a million and with only one city of over 75,000 (Manchester). A considerable share of the state's prosperity depends on tourist travel to and from the White Mountains, and to attract and hold this traffic good trunk-line highways are absolutely essential.

The problem of building and maintaining over 1,000 mi. of such roads with any sum of money which the financial condition of the state justified was a hard one, and to the late S. Percy Hooker, State Superintendent of Highways, who solved that problem in a very economical manner, great credit is due. The record of these gravel roads has amply justified Mr. Hooker's prediction that they would prove ideal for the conditions to be met. Mr. Hooker's policy has been ably continued by Frederic E. Everett, the present Commissioner.

Needless to say, the excellence of these roads was not attained, nor is it maintained, by accident; nor yet is it by any means due to extraordinarily good material. It is the result of a carefully worked out policy to concentrate on gravel-road construction, of good construction and of thoroughgoing and really efficient maintenance; and possibly, to some extent, it is due to topographic and climatic conditions.

General Road Plan of New Hampshire

As this article deals chiefly with the most important of these causes—maintenance—the general road policy of the state will be touched upon only briefly. Essentially, there are three main trunk highways north and south, the length of the state, and two main trunk highways east and west through the southern and northern parts of the state respectively, each built by coöperation between the state and the towns and by special appropriation. There are a few miles of state-built roads in wilderness sections of the state and there are numerous state-aid roads where the state has assisted the towns to build and maintain roads on important routes. The cost of building the 550 mi. of trunk line highways has averaged $4,000 per mi., including grading, drainage and culverts.

As to methods of construction, little needs to be said. It would be merely a rehearsal of first principles, with which every highway student is familiar, the practice of which, however, requires a large amount of rare good judgment and horse-sense. On these New Hampshire roads just as much attention has been paid to foundation and drainage as if the wearing surface was to be $15,000 a mile asphaltic concrete. The usual width of finished roadway is 21 ft., with a thickness of 10½ in. of gravel in the center and 3 in. at the sides. For compacting the gravel, corrugated, sectional, horse-drawn rollers are generally used.

The total appropriations for road maintenance from all sources have averaged about $250,000 per annum for the past three years, and with this sum the State Highway Department has improved and maintained about 1,000 mi. of gravel roads, or at an average annual cost of $250 per mi. (ranged from $119 to $850). It is not possible in many cases to draw any distinctive line between new construction and improvement (or maintenance), because there are instances where the original road needs little more than surfacing material, and the constant addition of new surfacing material is one of the prime requisites in gravel-road maintenance.

Patrol Maintenance One Secret of Fine Gravel Roads in New Hampshire

Starting with well-built gravel or dirt and gravel roads, the problem is to maintain them under severe motor-vehicle traffic. The successful method as demonstrated in New Hampshire has two prime essentials—honest, efficient and decently paid patrolmen and a willingness to spend $200, $300 per mi. per yr., or even more in an exceptional case, on plain gravel-road maintenance. It is in the latter essential that most highway departments fail: for while they show willingness to spend $600 to $1,000 per mi. per yr. to maintain bituminous roads, they generally balk at regularly spending $200 per mi. per yr. on dirt or gravel roads.

Patrolmen are local men, appointed on the recommendation of the selectmen of their towns. They are intelligent natives, not the ordinary type of laborer. Each patrolman is required to provide himself with the following equipment: Horse, dump cart, chain, shovel, pick, iron bar, hoe, rake, ax and brush hook. Any other necessary equipment (on exceptional sections tar kettles, etc.) is furnished by the state. The patrolman is expected to spend his whole working day of 9 hr., six days a week, on the job during the working season. His pay ranges from $3 to $3.50 per day.

In brief, the patrolman's duties are to frequently patrol his section and see that the road is clear of stones, broken

glass or anything of a foreign nature; to see that the ditches and shoulders are cleaned, the culverts clear and bushes cut, and to pay particular attention to the cleaning of the culverts and ditches after each rain. He is to patch any ruts and holes that may appear and drag the road after every rainstorm or shower or whenever the road surface is damp.

When necessary, a patrolman may hire, upon written consent of the division engineer, such assistants as he needs, but for each patrol section only a limited sum is ordinarily available each year—generally $1,000 or $1,200; and it is in the interest of all parties concerned (the state, the town and the patrolman) to make this money go as far as possible. If a patrolman spends a part of his allotment in hiring assistants, he has so much less for his own labor and for materials, which he also purchases out of his allotment—that is to say, his working season will be shorter. By good judgment on the part of the patrolman and division engineer this system works out admirably, and it makes the patrolman's job more than that of a day laborer, and thus it requires and develops a higher grade of intelligence and workmanship.

The patrolman makes daily postcard reports of his own time, assistants' time, material, work done and weather conditions. As the towns pay part of the maintenance costs, the patrolman must keep a record of his work in each town. Upon the authorization of the division engineer, the patrolman makes purchases of such material as is necessary for his work. Where small quantities are purchased at a time, bills are not sent in every week, as otherwise required, but a total bill is rendered at the end of each quarter—May 28, Aug. 28 and Nov. 27. The patrolman pays these bills, sending receipts promptly to the highway office, and at the end of the quarter he is reimbursed by the state.

There is no hourly allowance for overtime nor docking for short time. The patrolman is left largely to his own devices, but when he takes a day or a part of a day off he records the same and is paid only for the time he actually works. The working time of the patrolman is made up weekly from his daily post-card reports, and an order is sent him for presentation to the selectmen of the town or towns in which his section is, who give him a warrant on the town treasurer to cover his own pay, assistants' pay and material accounts. In cases of emergency, material may be purchased or assistants hired upon telephone order from the division engineer.

Every patrolman is provided by the state highway department with two cart signs with his number painted on them. He is also provided with a staff having a sign on top, which he carries on his cart; or when he is compelled to leave his section of road to go to a gravel pit, or for any other purpose, he leaves his staff in an upright position beside the road just at the point where he has left it, so that he may be found if necessary.

Each patrolman is provided with complaint blanks which he is to furnish to all parties wishing to register a "kick" in connection with the highway work. These complaints the patrolman is required to send to the division engineer. The patrolman is also expected to report all accidents which occur on his section of road and to take ordinary precautions on his own initiative to prevent accidents. He is also required to report any dangerous place or conditions on the roads or bridges of the town or towns which are not under his supervision, but he is to do this through the division engineer, and is particularly cautioned against criticizing the town authorities, and is urged to assist the town road authorities in every possible way in solving their problems.

TWO VIEWS ALONG TYPICAL NEW HAMPSHIRE GRAVEL ROADS, SHOWING TIMBERED SLOPES

A system of supervising and assisting patrolmen by having three of the most experienced men act as part-time foremen, traveling over the various patrol sections and giving instruction and advice, has been tried and proved fairly successful in one division, but the scheme of organization for the coming season is somewhat different. It is planned to have one experienced man give his whole time as inspector or foreman of patrolmen. The object is not so much that of checking the work of the patrolmen as to give them the benefit of the advice and experience of the inspector in solving their particular problems.

The state's highway patrolmen are all deputy fire wardens of the state forestry department and are furnished with badges and instructions in connection with these duties. In this work the patrolmen are governed by instructions from the forestry department, but report all